THE

GEOLOGICAL MAGAZINE

VOLUME LXI.

No. XII.—DECEMBER, 1924.

EDITORIAL NOTES.

THE news of the death of Sir Archibald Geikie on 10th November will have been received with profound regret by geologists throughout the world. He long ago established his claim to the leadership of our science in this country left vacant by the death of Sir Charles Lyell in 1875, and he has been universally recognized both at home and abroad as the foremost British geologist. It was once aptly said that on him had "fallen the mantle of Lyell, a mantle in which the warp of science and the weft of literature are so deftly interwoven". His luminous writings and vivid personality have undoubtedly added greatly to the esteem in which geology is now held by devotees of the other sciences and by the general public. The saying "nihil tetigit quod non ornavit" is indeed specially applicable to him.

A brief sketch of Sir Archibald's life and work up to 1890 will be found in the GEOLOGICAL MAGAZINE for that year, as one of the series of "Eminent Living Geologists". For the later period reference may be made to his autobiography "A Long Life's Work", reviewed last month. Another biography is obviously unnecessary but it is hoped to publish in an early number an appreciation of his influence on the geological work and thought of his time.

* * * * * *

SINCE the foundation of the Geological Society Club in 1824, members have dined together on the occasion of every ordinary meeting of the Society.

5th November, the date of the last meeting, was the centenary anniversary of the first Club dinner, and on this special occasion over a hundred guests, including distinguished representatives of kindred clubs, were invited to join the members at dinner.

The President, Dr. J. W. Evans, F.R.S., occupied the chair.

Sir W. Boyd Dawkins, proposing the toast of the kindred clubs, referred himself to "the pre-historic period" in the Club's history; for he was a member in 1874, when the Club celebrated its jubilee. In reminiscent mood, he described those old-time dinners as occasions when, by tacit agreement, the robust controversialists of the period observed at least a temporary truce.

In replying to the toast, Sir Charles Sherrington, President of the Royal Society, remarked that the latter could with some justice claim the Geological Society as a daughter society. He read out a choice selection of amusing light verse perpetrated by the old-time diners which he had found in a manuscript book of the Rev. Professor Thomas Wiltshire, a former Treasurer. Not all these poetic efforts had a direct bearing on geology.

Sir A. Smith Woodward next proposed the guests, and to this toast Sir Richard Gregory and Professor Schaffer, of Vienna, replied. Sir Richard never spoke in happier terms. Professor Schaffer remarked that the century of scientific comradeship and geological achievement which the occasion marked appealed to his imagination more than anything else in the geological past, and that the antiquity of the Club's snuff-box claimed his profound respect.

To the toast of the Geological Club, proposed by Sir William Bragg, the President replied by reminding those present of the great advances made in geological science since the Club was founded. A century ago, the four oldest Palaeozoic periods were unrecognized; Lyell, who was a founder of the Club, and survived to take part in its jubilee, had not subdivided the Tertiary; the Glacial period had not been established, nor had pre-historic man been discovered or the theory of evolution been formulated. Moreover, thin rock-sections and the petrological microscope were alike unknown.

Dr. Evans concluded his remarks by an appreciative reference to the responsibilities of the Club treasurer, and sketched his impressions of several holders of that office in the past. He proposed the toast of the past treasurers and more especially of the present treasurer, Mr. G. W. Lamplugh, to whom he paid a warm tribute.

Mr. Lamplugh, in reply, expressed his sense of indebtedness to his predecessor in the post, Professor W. W. Watts, whose sound policy he was content to continue during his own term of office. He pointed out the curious coincidence that at both the Jubilee and the Centenary dinners a John Evans presided.

Letters of greeting, signed by those present at the dinner, were forwarded to four honorary members who were unable to be present: Sir Archibald Geikie (whose death occurred on 10th November), Mr. William Whittaker, the Rev. Canon Edwin Hill, and Mr. E. T. Newton.

To each member and guest was presented a souvenir booklet giving the history of the Club, and a list of members during the century of its existence.

ORIGINAL ARTICLES.

Geology in the Service of Man.

By Professor W. W. Watts, Sc.D., LL.D., F.G.S., F.R.S.,
President of the Section.

(*Concluded from p. 509.*)

Evolution.

During the long period of time comprised in the history from the Cambrian Period onwards, the slow and persistent evolution of plant and animal life went forward and left ample record in the rocks. To warrant a belief in organic evolution, we are no longer solely dependent on reasoning founded on existing organisms or on the facts of their ontogeny and distribution. As M. Marcellin Boule says in his work on Fossil Man, " . . . pour tout ce qui a trait à l'évolution des êtres organisés en général, le dernier mot doit rester à la Paléontologie quand cette science est en mesure de parler clairement. Les plus fins travaux anatomiques, les comparaisons les plus approfondies, les raisonnements les plus ingénieux sur la morphologie des êtres actuels ne sauraient avoir la valeur démonstrative des documents tirés de la roche où ils sont enfouis et disposés dans leur ordre chronologique même." [1] Although we are only too painfully aware of the innumerable chances that conspire to prevent an animal or plant from securing immortality by preservation as a fossil, the finding of better preserved material, the more skilful preparation of it for examination, and the application to it of refined biological methods, such as careful dissection and the serial sections of Professor Sollas, are giving us more complete and accurate knowledge than ever before. It may now be confidently stated that many of the most crucial links in the chain of evolving life are in our hands, that they actually lived in the past, and that their fossil forms show their relationship to their predecessors and successors. The time has come when Darwin's famous chapter on the " Imperfection of the Geological Record ", an apology written with the most balanced criticism and unbiassed judgment, should be re-written and revised.

It is true that we seem as far as ever from unveiling the points of divergence of the great phyla, and we can but feel that the time from the beginning of the Cambrian Period onward is but a small part of the whole history of life on the earth. As with antiquarian research, each new discovery in geology, whether on the physical or the biological side, only brings these distant ages more fully into view and emphasizes their modernity and their likeness to our own time. Hutton's famous dictum that he saw " no vestige of a beginning,

[1] Marcellin Boule, *Les Hommes Fossiles*, 1923, p. 453.

no prospect of an end", is to-day more true than ever, when we regard the evidence of stratified rocks. But we know enough to convince us that within post-Cambrian time evolution has steadily proceeded from general to special, from simple to complex, from lower to higher efficiency.

In almost every subdivision of the animal kingdom, and in not a few branches of the vegetable kingdom, lines of descent and directions of specialization have been made out, sometimes visibly operating throughout whole Systems, but more usually through smaller divisions of the record; and this in the former kingdom not only among vertebrates but among the invertebrates and even their lower subkingdoms. It may even be stated that in methods of defence, in food procuring, in the attainment of favourable positions and attitudes, something very closely imitating what would be expected on the doctrine of the origin of species by "survival of the fittest" has again and again occurred.

The essence of evolution is unbroken sequence, and when we consider the extraordinary delicacy of the adjustment of life to its physical and organic environment, the mutual interdependence of life forms, and the necessity to them of such factors as favourable range of temperature, food, climatic conditions, soil, and the continuity of the "element" in or on which they live, it is most wonderful that in the vast lapse of post-Archaean time it has been possible for life to exist continuously, and continually to evolve, throughout those long ages. And this in spite of the fact that, although the main chain has been unbroken, conditions have, in many cases, been so unfavourable that whole groups have flourished and died out, while others have become so attenuated that only a few survivors have been left, highly restricted in distribution, to burgeon out again when the unfavourable conditions were removed, or in other places where conditions have again become more favourable to them.

That life has survived continuously in spite of the vicissitudes through which it has been compelled to pass, and the frequent convergence upon it of unfavourable conditions, may well be taken to heart by those who fear that civilization will be brought to an end by the misuse of the powers that itself has evolved. They may surely take courage and trust that the remedy for these evils will come, as it has in innumerable other cases, not from conventions and understandings that, as all history shows, will be mere scraps of paper, but from the intensive application to them of the very science which has evolved them.

Although the geological record is, and possibly will always remain, incomplete, it has yet proved remarkably representative, and certain outstanding facts have been made out which are sufficient to show that the lines of organic evolution as recorded in geology are in accordance with what is theoretically probable, and with

those taken by the evolution of domesticated organisms and by human arts and inventions.

1. There can be no doubt that the stages of organic evolution are correlated with and were actuated by the stages in the inorganic evolution of the earth itself. That climatic change was effective in inducing migration, and thus in sharpening the struggle for existence against both enemy organisms and changed physical environment; that extension and restriction of land and water areas in some cases brought about keener and more varied competition, change of habit or food, and in others the destruction of potential enemies and the securing of the advantages of a fair field for the survivors; and that activity of the earth-crust in such things as deposition and mountain-building provided conditions for the existence of an increased range of varieties and the consequent struggle between them. If we are not allowed to say that this brought about the survival of the fit, it at least caused the destruction of the unfit.

2. It may be stated as a biological law that every locality becomes "full" of life, forms arriving or evolving to take advantage of the special facilities offered. In consequence, resistance to the incursion of new forms, even if they are exceptionally equipped, is very great, and it is only occasionally that such new forms can make good their immigration. There are, of course, marked exceptions, but these generally occur when degeneration or overgrowth in size accompanied by neglect of means of defence have occurred, or when an area has been for so long sheltered from the wider and more general course of evolution that it has fallen seriously behindhand in the race.

The geological record gives indirect evidence of the same "filling" of areas in the past in the extraordinary slowness with which advanced types that have eventually made great headway established themselves after their introduction; the earliest fishes, reptiles, and mammals are cases in point. Imperfect as the first members of these groups undoubtedly were, they must, even shortly after their introduction, have possessed considerable advantages over the older and established forms with which they found themselves in competition. In size and strength they were doubtless inferior, and probably they must have taken long periods to make good their advantage. But in all such cases the new forms went for a long period into "retreat", and, in face of the apparent slowness of their evolution and the bitter competition to which they were subjected, it is remarkable that they overpassed the troubles of racial youth, and eventually took the place to which they were entitled in the scheme of life. It seems justifiable to believe that there must have been at least some well-equipped types which did not survive competition in these early stages, but went under with all their promise of future success. We can easily imagine that the survival of such, had it occurred, may have altered the whole

course of evolution and produced a life-story very different from that we know to-day, and of which we ourselves form no small part.

3. Not less remarkable than the period of "retreat" is that of booming development which at last came to each successful modification. In this connexion we can instance the "*pleine évolution*" of the graptolites, the euechinoids, ammonoids, and belemnoids, the fishes, reptiles, birds, and mammals, each in its own time. Each slowly but surely built up its supremacy, and then wantoned through long ages as the lord of creation in its own element and in its own day. Both the period of sanctuary and the subsequent boom can be closely paralleled by the case of many human inventions and in the occupations and history of mankind.

4. But while there are outstanding cases in which a line of advance is taken that is capable of successive improvements and leads on to continuous success, there are many other instances in which the line of advance, though temporarily advantageous, has only been carried through a limited number of stages, and eventually failed either by its inherent inadequacy or by imposing so heavy a burden on the economy of the organism that it was unable to bear the cost.

The only instance I need quote, though there are many others, is the use of defensive armour, spines, plates, hooks, horns, etc. These provide an obvious method of resistance to attack, and this defensive attitude has been practised by one group of organisms after another, but always with the same disastrous result, the imposition of a fatal strain on the organism to meet renewed, perfected, and more vigorous attack. The spinose graptolites and trilobites, the armoured fishes and reptiles, are cases in point, and in the last of these instances, at least, victory rested with the acquirement of swiftness in movement, accompanied by increasing power of attack such as is given by the development of teeth or claws or both. Again and again in the Tertiary Era one group of mammals after another, before, or more usually after, the attainment of great size, has taken to some means of sedentary defence, and in every case the cost of upkeep has been too great and the group has gone under. Every time the race has been to the swift, active, and strong, and those that trusted in "passive resistance, in "defence and not defiance", have gone under in competition with those that have been prepared to face the risks involved in attack. The fact that turtles and armadilloes have survived to the present endorses rather than vitiates the principle.

Other cases of rapid decline or sudden disappearance are more difficult to account for. The waning of the brachiopods, but not yet their disappearance, the disappearance of the pteridosperms, the rugose corals, the belemnoids and ammonoids synchronizing with the vanishing of many orders of reptiles, will long furnish subjects for research by biologists and geologists. And it may well be that the explanation will often lie along biological rather than physical

lines, such as those suggested for the graptolites; Lapworth pointed out that their disappearance—in spite of a brave effort of passive resistance—synchronized with the great development of fishes, and the assumption by them of many of the functions previously discharged by the trilobites. In other cases the explanation may be more in the direction of that given for the reptiles, to be referred to later.

The rarity in the geological record of some of the stages in evolution, and the absence of others which must surely have existed, may receive some explanation from what has frequently occurred in the history of human invention. If variants arise and are subjected to intense competition, they have no chance in the struggle for existence unless they show rapid improvement and development of the favourable variations within a few generations. Hence the numbers exhibiting each of the early stages of change will always be few and the chances of their preservation slight. Those who have tried to work out the stages in the history of an invention, for instance, will appreciate the rarity of "missing links" and the difficulty of filling in every step towards the later perfection. These are looked upon as "freaks" and, unless they present real and marked improvement, are never manufactured on a large scale. Their numbers consequently are few, and many of them are the victims of experiment and often do not survive the experience.

5. Perhaps the most wonderful result disclosed by a study of the later part of the geological record is the steady and unbroken evolution of brain from the earliest vertebrate animals to the present. The exceeding slowness of the process in its early stages is not less wonderful than its acceleration during the latest stages of geological history. The disappearance of so many orders of reptiles at the end of the Mesozoic Period, at the close of a long and most promising chain of evolution, indicates that there was some inherent weakness underlying the line of evolution entered upon by them, which proceeded so far and favourably that it was impossible to retrace the path. This may well have been connected with the substance or construction of brain and nerve. If so, this side of evolution has to be seriously reckoned with, and it may be that the fundamental weakness of physical as opposed to intellectual evolution brought this flourishing and well-developed group to its end.

It has, of course, been suggested by Searles V. Wood, jun.,[1] and others that the destruction of Mesozoic life types was brought about by physical changes; but, apart from the fact that the particular changes supposed by the former did not as a matter of fact occur, the entire explanation provides a cause utterly insufficient in comparison with the potency of organic struggle against creatures better endowed with warm blood, adequate brain substance, and the activity and enterprise springing therefrom.

[1] *Phil. Mag.*, vol. xxiii, 1862.

In spite of the evidence of acceleration as the higher ranks of animals are reached, and in spite of the extraordinary efficiency of the human brain and all the benefits to the organism it brings about, we may well be appalled by the aeons which have been used up and the millions of varieties which have passed away in the production of this, the most efficient scientific apparatus yet invented or evolved.

6. But if it has taken long ages to evolve an animal capable of a broader geographical distribution than any other, with a constitution capable of withstanding the widest ranges of heat and cold, and of peopling the world from its tropical deserts to its polar wastes; and to endow him with a brain by virtue of which he has made himself master of the earth and all its living inhabitants; it has taken no less time for the evolution of the many factors without which his present success would have been impossible. To pick out a single instance, probably few things in the whole story of life have been more fruitful in effect than the appearance of the grasses in late Eocene times, followed by their rapid evolution and spread in the Oligocene and under the direction of the critical events of the Miocene Period. Starkie Gardner, in an admirable paper, first drew attention to the vital importance to the animal evolution of the world in general, and to the welfare of man in particular, of this step forward. It was followed by great changes in the insect world, by the rapid production of herbivorous mammals endowed with speed, great migratory powers, special dental and other anatomical adjustment to the new foods, and the institution in their herds of a discipline, subordination, and leadership which are almost tribal. These last qualities were rendered doubly necessary by the consequent rapid development of carnivora, and the need for scrapping passive and even active means of defence in order to secure the power, speed, and reserve necessary to follow their food harvests over great stretches of country. At the same time the habits and instincts thus brought about were those which man, by domestication, has been able to turn to his own ends. Thus at a blow, as the outcome of this stage of Tertiary evolution, there became available for mankind not only his chief plant food and drink, his luxuries as well as his necessaries, but his chief animal foods, together with his aid from the speed, strength, service, and endurance of the animals which he domesticated, and to which he assumed the position of leader of the herd.

But while with the aid just described it was possible for mankind to progress far on the road of civilization, progress would have been stopped, and as a matter of fact was seriously retarded, until the discovery and utilization of the solar energy stored up in the earth's crust during the Carboniferous and subsequent Periods in the form of coal and other fossil fuels. The very exceptional conditions, climatal, geographical, and botanical, requisite for coal formation, occurred all too seldom in geological history, but

it has so happened that few areas of the earth are devoid of coal belonging to one Period or another; and the shaping of kingdoms and dominions has been such as to include supplies of fuel in most of them. Whatever may be the main sources of energy in the future, radiant, intratelluric, hydraulic, tidal, atomic, we have been largely dependent in the past, and probably shall continue to depend for many years to come, on that portion of the solar energy stored up by vegetation, and especially on that preserved in the earth-crust in the form of coal.

But again civilization must have been greatly hampered or driven into a different course but for the agencies which have sorted out from the medley of materials of which the earth is composed, simple compounds or aggregates of compounds, or in rarer cases simple elements, in such a form that they are available for human use without the expenditure on them of excessive quantities of energy. The concentration of metalliferous ores, salines, and the host of other mineral resources has made perhaps the most important contribution of all to the latest stage—in good and evil—attained by civilization.

Finally, doubt may be expressed whether man could have attained his present position if he had not made his appearance comparatively soon after a period of intense earth activity, when broad areas of newly raised sediment were available for occupation, when the agents of denudation and renewal were in active operation, and when a wave of rapid organic evolution was active. And a conjecture may be permitted that human evolution itself was probably hastened by the latest climatal severity through which the earth passed, the effects of which are only slowly passing away.

Much of what has just been said may revive recollection of an old Swiss guide-book which praised the beneficence of Providence in directing the dreaded avalanches "into the desolate and uninhabited valley of the Trumleten Thal and in sheltering from them the beautiful, fertile, and inhabited valley of Lauterbrunnen". However, it is far from my intention to imply that "everything is for the best in this best of all possible worlds", but only to point out in reviewing the long chain of events of which we see the present end-product in civilized man, that within the ken of the geologist there have been many critical stages in the earth's history when any marked change in the conditions which then prevailed must inevitably have reacted profoundly upon the development of the human race when at long last it stepped out from the lower ranks to take the earth as its rightful possession.

Conclusion.

A review of the history and present position of geology shows that its better-known services to mankind have been in relation to the foundations on which industrial development and modern civilization have been built—the mineral resources of the earth. These are many

and various, all of them explored by geological methods. In every application of them we are again brought back to the primal essentials —water, iron, and fuel—and it is in the discovery and exploitation of these that the services of geology have been of especial value.

But in the course of the development of both the economic and the scientific sides of geology the principles discovered and elaborated have fertilized and enriched human thought as expressed, not only in other sciences but also in the sphere of literature. As it has become more precise and is able to give a more accurate and detailed picture of the stages through which the earth passed during the long story unfolded by the study of the stratified rocks, it has shown that the earth, though only a minute fraction of the visible universe, has had a wonderful and individual history of its own. The keynote of this history is evolution, the dream of philosophers from the earliest times, now passed from the realm of hypothesis into that of established theory.

We are able to watch the evolution of the oceans and continents, of the distribution of landscape and climates, and of the long succession of living beings on the earth, throughout many millions of years. During these ages we see the action of the same chemical and physical laws as are now in operation, modified perhaps in scale or scope, producing geographical and biological results comparable with those of to-day. Hutton and Lyell discovered for us in the present a key to unlock the secrets of the past; the history thus revealed illuminates and explains many of the phenomena of the present.

And the outcome of it all is to endow man with a simple and worthy conception of the story of creation, and to fill him with reverence for the wondrous scheme which, unrolling through the ages, without haste, without rest, has prepared the world for man's dominion and made him fit and able to occupy it.

I desire to express my thanks to Mr. G. W. Lamplugh, Professor E. W. MacBride, Professor W. G. Fearnsides, and Mr. G. S. Sweeting for kind assistance in the preparation of this address.

On a Specimen of Fossil Wood from King's Arms Pit, Tiptree, Essex.

By W. N. Edwards, British Museum (Nat. Hist.).

(Published by permission of the Trustees of the British Museum.)

An examination of sections of the silicified wood from the King's Arms Pit, Tiptree, revealed at once that the structure was of the *Dadoxylon* type, and the absence of growth rings strongly suggested affinity with the Palaeozoic woods included in that genus, many of which are allied to *Cordaites* rather than to the araucarians. Among known silicified woods, a close comparison was possible only with those from the Corley (Enville) Group of the Midlands,

now regarded as probably Upper Carboniferous, and not Permian. In particular, certain specimens from Allesley, near Coventry, Warwickshire, were extremely similar in colour and in the mode of silicification, as well as in their minute structure. The anatomical resemblances may be briefly summarized as follows: annual rings absent; bordered pits on radial walls of tracheids 12–15μ in diameter, compressed, polygonal and in 2–4 rows; medullary rays uniseriate or partly biserate, and one to about thirty cells in height. The field pitting is not shown in any of the Allesley specimens I have examined, which are mostly poorly preserved, but here and there in the Tiptree specimen one or two large oval pits could be distinguished in the field.

A piece of wood from Allesley in the museum of the Geological Survey was identified by Dr. Kidston as *Dadoxylon* (*Cordaites*) *brandlingi* (L. and H.), but the preservation is extremely poor.

Another species with which comparison is possible is *Dadoxylon kayi* Arber. The original material from the Halesowen Sandstone, Witley, Worcs., was calcified, but derived silicified wood from the Bunter Pebble Bed at Hungry Hatton, near Market Drayton, Shropshire, was referred by Dr. Kidston to this species.

It does not seem to me possible at present to distinguish Palaeozoic petrified woods of the *Dadoxylon* (or *Cordaites*) type when only the secondary wood is preserved, and especially when the preservation is imperfect. I therefore refer to the Tiptree fragment as *Dadoxylon* sp., but consider it to be specifically identical with wood found in the Allesley Conglomerate (? Upper Carboniferous) and other localities in Warwickshire. This wood is silicified, whereas most of the Carboniferous plant petrifactions are calcified, and it seems highly probable that the silicified woods of the Bunter Pebble Bed of the Midlands were derived from the Corley (Enville) Group. The wood has also been found in gravels near Leamington and elsewhere.

The Pliocene Age of the Brain Valley Gravels, Essex.

By J. W. Gregory, D.Sc., F.R.S.

THE fragment of silicified tree stem identified in the preceding paper by Mr. W. N. Edwards as a *Dadoxylon* from the Upper Carboniferous of Warwickshire was found in the gravel pit at Tiptree Heath just west of the King's Arms. This pit is at 269 feet above sea-level on the summit of the ridge that runs from Wickham Bishop, towards Colchester. The gravel is part of an extensive sheet which is shown on the Geological Survey Map (sheet 47) as Glacial Gravel. Dr. A. E. Salter (*Proc. Geol. Soc.*, xix, 1905, p. 31) recorded from this pit Bunter debris, sarsens, radiolarian chert, rhyolite, and the green ash associated with it, and Carboniferous chert, with crinoids. This gravel is the highest part of the sheet, which in 1914, I classified as the Brain Valley

Gravel from its occurrence in the Brain Valley near Witham, where it had been described by Sir J. Prestwich (*Q.J.G.S.*, vol. xlvi, 1890, p. 132) who interpreted it as an inland outlier of the Wesselton beds. The gravel descends from Tiptree gradually to the N. to the level of 120 feet near Birch, and west of Colchester, and to about 100 feet to the east of that town.

This gravel is one of a long series formed during the denudation of central Essex. Its north-eastern extension rests on the plain upon which to the east of Colchester was deposited the Red Crag of Beaumont and Great Oakley. The plain around those villages is certainly Pliocene. The gradual rise of the gravels westward indicates that they were laid down on the inland extension of the Pliocene plain of marine or estuarine erosion.[1] The gravel was later in age than the Danbury Gravels ; and it was probably pre-glacial as it contains neither Jurassic material from the north-north-west nor Tyneside basalt or other northern rocks, such as are found in the boulder clay and glacial gravels at lower levels in the neighbourhood ; moreover, it does not show any other evidence of glacial action.

There appear to be two available criteria for the glacial origin of Essex gravels. The main test is that the glacial beds should contain north-western Jurassic material or northern igneous rocks which have been brought in by ice and be derived directly from it. Foreign material which has been washed out of boulder clay, such as is found in many of the recent river gravels, is not evidence of the glacial nature of the bed in which it occurs. The second criterion is less reliable ; but if a gravel contains in most of its layers large unrolled nodules of flint, in a locality so far from a chalk outcrop that they must have been floated to their present position, such a gravel may be regarded as glacial, although when it was laid down there may not have been any extraneous ice in the neighbourhood. The presence, however, of occasional unrolled flint nodules is insufficient to indicate glacial conditions ; for they may have been carried by floating vegetation or by ice in exceptionally severe winters. Ice rafts are formed in the rivers of the Baltic plain every year ; yet they are not regarded as constituting glacial conditions. It appears inappropriate to apply the term " glacial " to gravels which have received a contribution of material from a few miles upstream by means of ice-rafts, perhaps one a century.

According to these criteria the sheet of gravel which extends from Tiptree to the neighbourhood of Colchester is not "glacial" gravel. The climate may have been slightly colder than at present, for the Crag at Oakley contains some northern species and the gravels of Tiptree and Birch contain unrolled chalk flints which may have been carried by occasional ice rafts.

As this sheet of gravel is probably pre-glacial, since it contains

[1] The objection that this view assumes some uneven uplift of the country in the Upper Pliocene or Pleistocene may be answered by reference to Professor Boswell's paper, GEOL. MAG., 1915, pp. 198–206.

no Jurassic material other than perhaps Rhaxella chert, and is later than the Danbury Gravels, which were formed on a higher and more denuded plain, I proposed the separation of this gravel as a distinct subdivision—the Brain Valley Gravels. The name was given from the occurrence in the lower part of the Brain Valley which was described by Prestwich. It was also suggested that some of the materials in this and some associated gravels came from the southern Midlands along the valleys of the Upper Lea and the Upper Ouse. Mr. Edwards' determination that the specimen of silicified fossil wood from Tiptree comes from the southern Midlands, where it occurs in situ near Coventry, and in gravels around Leamington, is in conformity with that suggestion. That a river from the southern Midlands reached Essex along the valley of the Upper Ouse and Upper Lea was suggested partly from the occurrence of Rhaxella chert from North Oxfordshire and the adjacent part of Buckinghamshire in the Essex gravels, where it was discovered by Mr. Percy Thompson (*Essex Naturalist*, xviii, 1914, pp. 256–60). Rhaxella chert was found near Cromer by Dr. Salter several years ago (Gregory, *Essex Rivers*, 1922, p. 41), and it has also been found there by Dr. Johnstone (G. Slater, *Proc. Geol. Assoc.*, xxxiv, 1923, p. 225). In recording its occurrence in Cromer I remarked that the Yorkshire locality was a natural source of the Rhaxella chert at Cromer ; but it may have come from Buckinghamshire down the valley of the Nene. All the East Anglian Rhaxella chert may therefore have come from the south Midland outcrop. It is a significant fact that the only other fossil found in the mid-Essex gravels to which a restricted locality can be assigned has also come from the southern Midlands, from about 30 miles north of the Arngrove-Brill outcrop of the Rhaxella chert.

On a Supposed Glacier-lake in West Cumberland.

By J. D. Kendall.

In Appendix I to the *Summary of Progress of the Geological Survey for* 1921, pp. 118–28, "The Retreat of the Lake District Ice-cap" is dealt with.

The Appendix describes a number of gravel masses on a part of the western flank of the Lake mountains, which are shown on drawing No. 1, herewith, and marked X. A part of each mass (*a*) is said to have been formed when the surface of the water in which they were deposited was about 600 feet above Ordnance datum. Another portion (*b*) when that surface was some feet below the 700 contour. A third part of each mass (*c*) is considered to have been laid down at a water level a few feet above the 700 contour, and the highest accumulations (*d*) are said to have been assembled when the surface of the water stood about 800 feet A.O.D. The author of the Appendix, Mr. E. E. L. Dixon, considers that these deposits were formed in a glacier-lake, bounded on the west by a glacier occupying

the Irish Sea, and which is supposed to have acted as the lake barrier from about Owsen Fell (A, drawing No. 1) to about Dent (B, drawing No. 1), the col through which the overflow water is supposed to have escaped when the lake surface was about 600 feet A.O.D., being at C, Fig. 1. The Appendix later states that "Overflows corresponding to some or all of the higher stages *may have existed*[1] between Flat Fall (D drawing No. 1) and Blakeley Raise (E, drawing No. 1), as would appear from the contour lines, *but this ground has not yet been examined.*[1] Later, it is stated in the Appendix that "After the evacuation of Lower Ennerdale by the Lake District ice the Irish Sea ice appears to have readvanced to such an extent that it may well have closed the outlet of the glacier-lake at 600 feet between Dent and Flat Fell, and thus have raised the lake-level to 800 feet, with an outlet over the ice or between Flat Fell and Blakeley Raise". It is not shown how this could be. The 800 feet outlet being an important adjunct of the suggested lake, its position should have been clearly explained so that it might have been checked by the important facts in the immediate neighbourhood relating to boulder distribution.

In another reference to the gravel masses, it is stated that "All the members except that at 600 feet are deflected sharply southward on emerging from the hills and to the coastal plain". The map accompanying the Appendix does not seem to support this statement. According to it, at Cogra the 800 feet gravel deposit lies northward from Rakegill Beck as well as southward. At Gillbeck the deposits turn more northward than southward.

Between 1879 and 1883 I made many observations on the glacial phenomena of the Lake District, and particularly on the area of the supposed glacier-lake and the country adjoining it. At the Jubilee meeting of the British Association, in York, 1881, I read a paper on "The Glacial Deposits of West Cumberland", and later published it in the *Transactions of the Cumberland Association for the Advancement of Literature and Science*, part vii, 1881–2. In my rambles through the country referred to in the Appendix, I saw a number of facts which do not appear to have been observed by the Geological Survey. For instance, the distribution of boulders is scarcely referred to in the Appendix, the only notice of importance being the following, which is made under the head of the Lamplugh Outwash Fan, between 680 and 1,000 feet A.O.D.: "The presence in the *lower* parts of the fan, here and elsewhere,[2] of great blocks of Carboniferous limestone from the outcrop to the west, shows that at some period before the separation of the Lake District Ice-cap from the Irish Sea Ice-sheet the latter had invaded the front of the fells to heights of over 800 feet." There is no evidence given of the Irish Sea ice-sheet.

[1] Italics by J. D. K.

[2] Other parts of the mass besides that along Wisenholm Beck.

In May, 1880, I read a paper on the "Distribution of Boulders"[1] from which the following is taken: "In examining the boulders in Whicham Valley, I found Eskdale and Criffell granite, Ennerdale Syenite, and St. Bees Sandstone, as far up the valley as Whicham Hall, which is about a mile from the mouth of the valley. The icy stream by which these boulders were borne must therefore have made a right-angled turn round the south end of Black Combe, for none of them can have come down the valley, as there is no rock of the kinds mentioned in that direction. The boulder current has also been deflected in a similar manner up the vale of Duddon, and towards the head of Ennerdale, for at the south end of that lake there are numerous boulders of St. Bees and Whitehaven Sandstones, Carboniferous limestone, various Coal Measure rocks, and Criffell Granite . . . Again in Cogra Valley there has been a similar movement up-hill, for we find boulders of Carboniferous limestone resting on Skiddaw Slate, nearly at the top end of the valley. Some of the boulders are very large, and many of them are severely glaciated. They occur both in tough boulder Clay and directly on the bare Slate. Up the sides of the valley I have found them at an altitude of 1,100 feet. One, in the mouth of the Wisenholm Valley, at an altitude of about 800 feet, measures 8 by 5 by 4 feet. There is no rock of this kind *in situ* at an altitude anything approaching this nearer than Caldbeck. But the most remarkable feature of these boulders is that they must have gone up the Valley, that is, in a direction from the low ground fringing the seashore, towards the hilltops, whilst at the same time they occur in true till or boulder Clay . . . On the watershed between the head of Uldale and Ennerdale, just opposite Ennerdale Bridge, and not far from Cockhow, about 700 feet above the level of the sea, there is an immense accumulation of gravel, consisting of Whitehaven and St. Bees Sandstones, Carboniferous limestone, Syenite, Lavas, and Ashes, Skiddaw Slates and several Coal Measure rocks. The underlying strata are Skiddaw Slates, and there is no Carboniferous limestone, St. Bees or Whitehaven Sandstone, or any other Coal Measure rock within two or three miles, and there is none at the same or a higher level within five miles, that is, on Dean Moor, between which place and the gravel deposit under consideration, ground several hundred feet lower intervenes. But the most remarkable thing is, that although this gravel has been carried up to such a height, and deposited on the hill top, none of it seems to have gone over the watershed into Uldale. I examined the upper part of that valley most carefully, but only found a single piece of St. Bees Sandstone, and that was small, and lying in such a position that I prefer to leave it out of consideration as it might very possibly have been conveyed there by human agency. What makes the absence from Uldale of rocks such as St. Bees and Whitehaven Sandstone still more noticeable is

[1] *Trans. of the Cumberland Association for the Advancement of Literature and Science*, part v, 1879–80.

that there are boulders of those rocks on the side of Dent, 200 feet above the level of the watershed of the valley that runs through between Dent and Kinniside (Flat Fell) to join Uldale."

A few other notes on boulder distribution may here be added, as they are important. On the north side of Dent, opposite Flat Fell end, at an altitude of 800 feet, I found a boulder of Whitehaven Sandstone, subangular, and about 12 by 9 by 6 inches. On the watershed between Cogra and Wisenholm, at an altitude of 900 feet, there is a boulder of Carboniferous limestone 3½ by 2 by 1¼ feet. Near the summit of High Hows—at 950 feet A.O.D. —are several boulders of that rock. In Wisenholm Valley, near the sheepfold, at an altitude of about 930 feet, there are a great many boulders of Carboniferous limestone of all sizes up to 4 by 3 by 2½ feet. Many of them are partly embedded in a gravelly pinel (boulder clay) which contains boulders of syenite, ash rock, Skiddaw Slate, and red sandstone from the Coal Measures. On the summit of High Hows—1,010 feet A.O.D.—I found boulders of red sandstone and grey sandstone from the Coal Measures. From the puddle-trench of the Cogra Reservoir a large number of boulders of Carboniferous limestone were unearthed. One was 3 by 2 by 2 feet and another a little less. Some of them were smoothed and striated, and all set in stiff blue clay. At the high end of the Cogra Valley in boulder clay, at 780 feet A.O.D. there were boulders of Carboniferous limestone some 12 inches in diameter, also of syenite, ash rock, and Whitehaven Sandstone. Boulders of syenite (the rock *in situ* is shown on drawing No. 1) occur in nearly every part of the area shown by drawing No. 1 west and north of the rock in place. I have also found them at Carlisle and at Haydon Bridge in the Tyne valley. They occur in great numbers along the West Cumberland coast and also in Furness; J. G. Goodchild found them on Stainmore.

The remarkable occurrence of widely scattered deposits of boulders from different parts of the Lake District, and the immediately surrounding area, has a most important bearing on the origin of the glacial deposits of those areas. A map illustrative of this part of the subject is given in "The Glacial Deposits of West Cumberland". It may be repeated here, that boulders from the quartz-felsite dyke on Armboth Fell, near Thirlmere, are found at Troutbeck and Penrith, at Aspatria, Flimby, St. Bees, and Ravenglass. Boulders of St. John's quartz-felsite I have found at Carlisle, Bullgill, Flimby and St. Bees, etc.

Before a properly considered opinion can be reached as to whether any Irish Sea glacier could form the western boundary of a lake such as is assumed in the Appendix, it is necessary to consider for a while the glaciation of the middle and northern part of Scotland and of part of Northern Ireland. Drawing No. 2 shows by plain arrows the courses taken by glaciers in those areas in travelling either to the North Sea or to the Atlantic Ocean. The directions

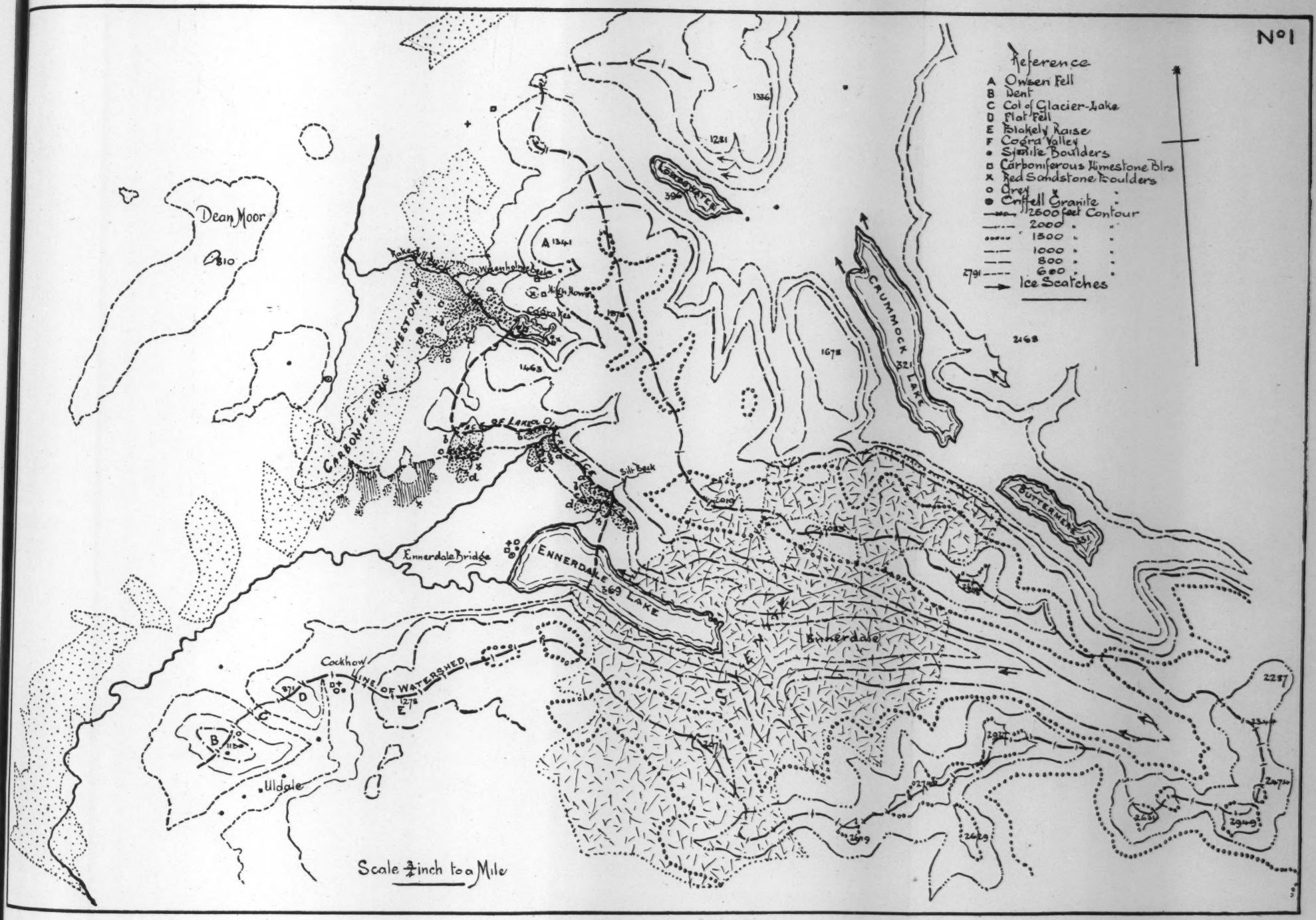

FIG. 1.—Position of supposed Glacier-Lake.

[To face p. 544.

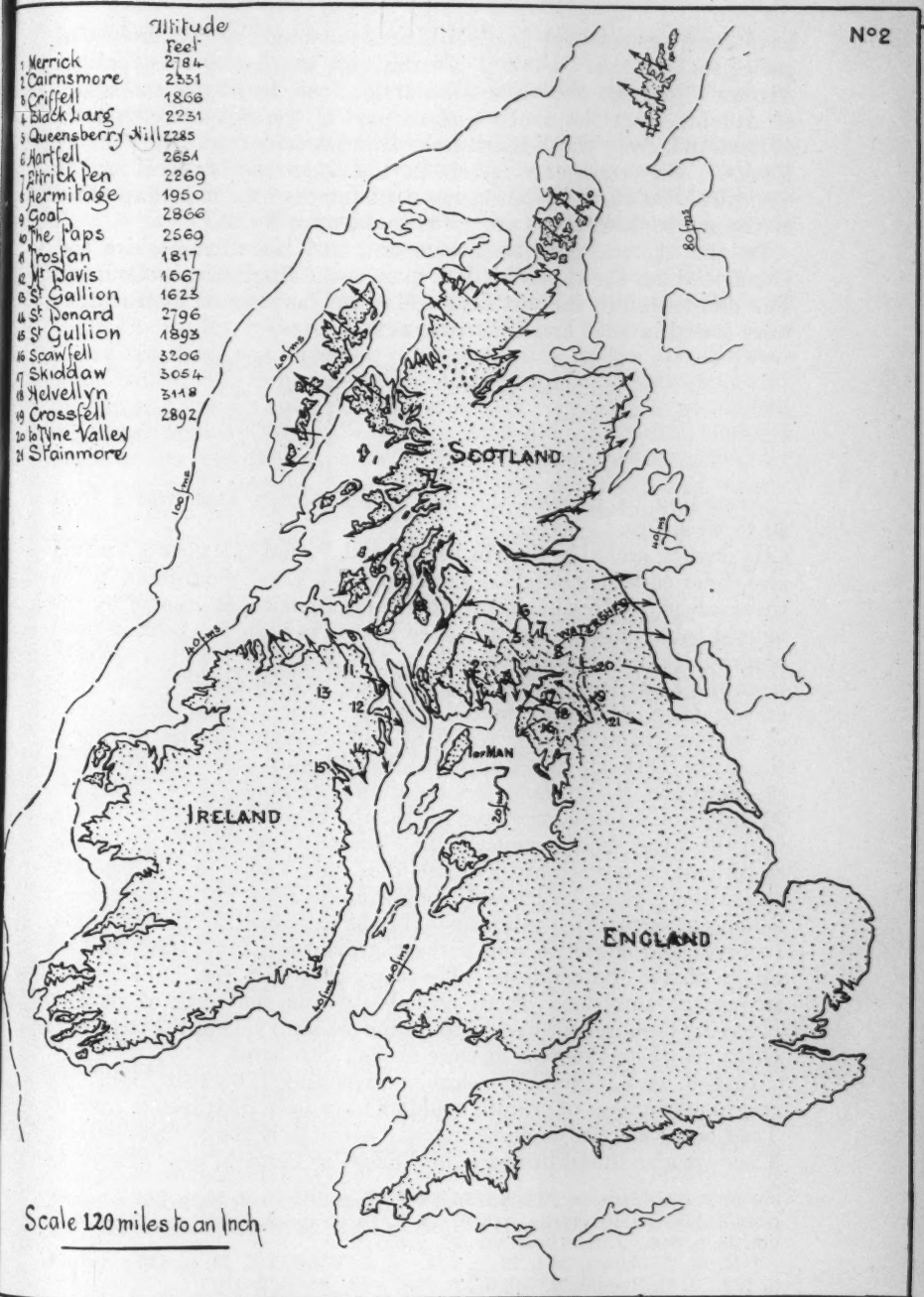

FIG. 2.—Map to illustrate direction of ice scratches.

have been ascertained in detail, and recorded by a number of geologists in the *Quarterly Journal of the Geological Society*.[1] Arrows show also the directions of ice-flows from the east coast of Antrim, from the south-western part of the Southern Uplands of Scotland, from the English Lake District, and from the Pennine Range. Directions are given in the *Quarterly Journal of the Geological Society*.[2] The altitudes of a number of the most important elevations in these areas are given in drawing No. 2.

In the eastern part of Antrim and in Kirkcudbrightshire and Dumfriesshire, the rainfall is less than in the English Lake Country. The annual fall in the wettest parts of the last-named district that were tested in 1868 and 1869 were as follows :—

The Sty . . .	202·8 inches
Sprinkling Tarn . .	126·8 ,,
Styhead . . .	132·2 ,,
Taylor Gill . .	178·6 ,,
Helvellyn . . .	105·3 ,,

According to Buchan the fall in the Scotch area varies from 40 to 80 inches.

It is very probable that in the Glacial Period the snowfall would also differ correspondingly. Further, the highest mountains in the three areas, at present, are in the Lake District, as shown by the figured table on drawing No. 2, so that it is very unlikely, if these orographical differences existed in the Ice Age, that the glaciers from the Lake District mountains would be dominated by the Irish and Scottish ice if they came in contact with it. The distribution of boulders from Thirlmere and St. John's round the north side of the Lake District mountains to Bullgill and then southward to St. Bees and Ravenglass, the occurrence of boulders of Ennerdale Syenite to the south, west and north, and also eastward, by Carlisle, into the Tyne Valley, whilst Criffell boulders travelled to the south, south-east, and eastward through the Tyne Valley and south-eastwards along Eden Valley and over Stainmore into Yorkshire, present a series of facts which cannot possibly be explained by glacier action. Icebergs and shore-ice, and perhaps ground-ice, must have effected much of the distribution. The clay, in which the boulders are frequently embedded, in all probability was the work of glaciers, it having been mainly deposited on the seaward side of the numerous positions where the glaciers were broken into bergs.

Criffell, in Kirkcudbrightshire, is now only 1866 feet high. An enormous number of granite boulders have been distributed from it. They occur at Carlisle and generally over the north of Cumberland. They are also found in the Tyne Valley, at Penrith, over Stainmore

[1] J. F. Jamieson, vol. 18, p. 164 ; vol. 21, p. 161 ; vol. 22, p. 261 ; vol. 38, p. 160. Jas. Geikie, vol. 34, p. 819. B. N. Peach and J. Horne, vol. 35, p. 778 ; vol. 36, p. 648. J. R. Kilroe, vol. 44, p. 827.

[2] R. H. Tiddeman, vol. 28, p. 471. J. C. Ward, vol. 29, p. 422 ; vol. 31, p. 152. J. G. Goodchild, vol. 31, p. 55.

into Yorkshire, along the sea coast of Cumberland into Lancashire, at Macclesfield, Colwyn Bay, Moel-y-Tryfan, and as far south as Wolverhampton (see the "Erratic Blocks of the West of England and East Wales").[1]

When the Lower Boulder Clay came into existence, in the area under consideration, the rocky portion of the district and of southern Scotland and north-eastern Ulster was probably about 600 feet lower than it is to-day, the surface of the sea then coasting on a line which would not be far from the 600 feet contour of our present maps. The lowest parts of all the main valleys in the Lake District—except that in which Hawes Water occurs—would then be well below the sea-level, Wastwater would be 400 feet below, Lowestwater about 200 feet, and Derwentwater about 360 feet. The distance from Criffell to the site of the supposed glacier-lake is about 25 miles. The altitude of the surface of the glacier at Criffell might not exceed 900 feet above the sea-level at the time the boulders began to be distributed, that is when the icebergs were floating southerly and easterly from Scotland and northerly and north-easterly from Buttermere, Crummock, and Borrowdale by Bassenthwaite. The altitude of the ice at Criffell being low, the glacier would not travel far before the sea end, at ordinary rates of movement and ablation, would break up into bergs, which would scatter their included pieces of rock here and there as the ice melted. A glacier from Criffell, under the circumstances indicated, could not possibly reach the assumed lake-site, nor within 20 miles of it. If we take into the calculation the glaciers from Cairnsmore or Merrick in Kirkcudbrightshire, or from Queensberry Hill in Dumfriesshire, the result would be practically the same, for although these mountains are higher than Criffell they are much farther away.

By degrees the land sank about 400 feet during the formation of the Lower Boulder Clay. It afterwards rose to about the position it had before the previous sinking. A second depression then occurred during the formation of the Upper Boulder Clay. That seems, from the dispersed boulders, to have been about 1,400 feet or more, which would make the waterline about or perhaps above the 2,000 feet contour of to-day.

During the formation of the Lower Boulder Clay there would be an open channel from the Irish Sea, across north Cumberland, and through the Tyne Valley to the North Sea. When, from sinking of the land during the formation of this clay, the sea had reached the line of the present 800 feet contour, there would be a channel through by Dunmail Raise, Troutbeck Station, Mungrisdale, and Sebergham into the north Cumberland channel just referred to. A further sinking of about 100 feet would bring into existence a channel through by Troutbeck Station into Edenside and another by Shap Summit and Tebay southwards towards Milnthorpe.

[1] *Quart. Journ. Geol. Soc.*, vol. xxxv, p. 425.

Along the latter course Shap Fell granite would be distributed. A sinking of the land about 800 feet below its level at the commencement of the Lower Boulder Clay period would bring into existence a channel over Stainmore into Yorkshire.

These channels coming into existence at widely different times, the currents in them would most probably not interfere with one another. These currents were probably produced as follows: The eastern current from Criffell over north Cumberland and through the Tyne Valley would most likely be created by the water exuding from Kirkcudbrightshire and Dumfriesshire snowfields and glaciers as well as from the snowfields and ice on the north side of the Lake District. The southern flow along the West Cumberland coast would be part of that formed by the melting of the snow and ice of part of Kirkcudbrightshire and N.E. Antrim. The northward, westward, and south-western currents which distributed the syenite-bearing bergs from Ennerdale and Buttermere into the eastern and southern currents would be produced by the effluent waters from the snow and ice in those two valleys. The waters from Ennerdale and Eskdale would unite with the southward current from Kirkcudbrightshire. Eskdale granite boulders turned southwards soon after leaving the rock in place. The water from the snow and ice in and adjoining Thirlmere Valley would give rise to the current flowing by Mungrisdale northwards to Carlisle. That current might also turn westward and join the Borrowdale-Bassenthwaite current flowing partly westward to unite with the southerly stream and partly north-eastward to join the eastern current across north Cumberland. At the same, or some other time, it might turn eastward into Eden Valley. The waters from the High Street range, Howgill Fells, and Crossfell range would form the current over Stainmore.

All these waters would carry some mud, but after the bergs were formed that would soon be deposited, as it is, for example, in the Lake of Geneva. The fresh water, being lighter than sea water, would probably flow at and near the surface of the latter, so that a comparatively small body of moving water in each of the different channels would produce a current sufficient to move the bergs in the direction travelled by the boulders.

If it be assumed that a glacier from Criffell was over 1,000 feet thick near Ennerdale, it would have had to be several thousand feet thick at Criffell, which would be impossible. So far as I know, there is not any evidence that such conditions ever existed as would fill the Irish Sea with an enormous body of glacier-ice moving southward from South-west Scotland and North-east Antrim. In the Appendix, the ice-sheet seems to be assumed. There is not any evidence of it. Moreover, the time at which the assumption is made was supposed to be a period of recession of the Lake District glaciers. If they were receding, why was the Irish Sea glacier advancing, as the Appendix says it did ?

In his " Glacial Phenomena of the Eden Valley and the Western

Part of the Yorkshire Dale District ",[1] J. G. Goodchild says: "At Swindale Head, at an elevation of about 1,350 feet above the sea . . . we have a stiff clayey matrix of a deep red colour, which is derived from the wear and tear of the Permian rocks of the Eden Valley. Among the stones several recognizable fragments of Brockram may be detected, thus proving that this till, like the very different upper drift, has moved upwards from the Eden Valley, and that both drifts have moved in the same direction. It should be noted that this red till is nearly 700 feet higher than any of the red rocks from which it must have been derived." Goodchild does not explain how the glacier conveyed the red clayey matter 700 feet uphill. I think, however, he is wrong in that conclusion. The red matrix was more probably derived from the red beds of the Upper Yoredales which occur in the neighbourhood, and at a higher level. The boulders would be carried by bergs sailing along the Eden Valley.

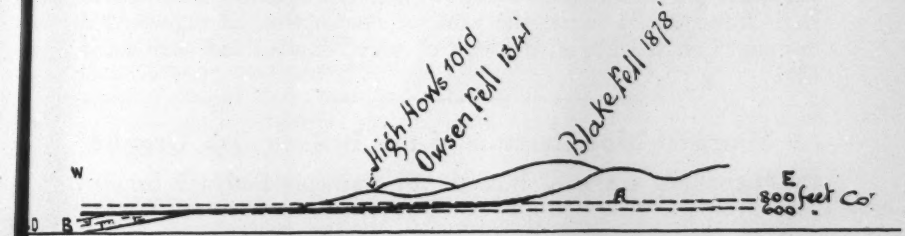

FIG. 3.—Section of Cogra Valley. —— Boulder Clay; A, Skiddaw Slate; B, Carboniferous Limestone. Scale, 1 inch to a mile.

There is another way of looking at the matter. It is most unlikely that a glacier moving down Ennerdale would be stopped at the position indicated by the line marked on the drawing in the Appendix (and in long dots overwritten by "Face of Lake District ice" on drawing No. 1 herewith) when the Irish Sea ice had, at the supposed glacier-lake, a thickness of over 800 feet. On both sides of Ennerdale there would then be large ice-forming areas, only 2 to 8 miles from the supposed lake, at altitudes of more than 2,500 feet A.O.D., whilst the ground from which the assumed Irish Sea glacier started was not higher, if so high, and from 25 to 50 miles away.

There is a third argument against the existence of this glacier-lake. If the overflow water from it had passed through the valley between Dent and Flat Fell, as supposed in the Appendix, we should surely have found, along Uldale valley, gravel formed of Carboniferous limestone, St. Bees Sandstone, and Whitehaven Sandstone similar to that in the heaps south of Cockhow, above referred to, but as already stated, I did not find any that could be safely used as evidence.

General remarks.—As previously mentioned, there is in Cogra Valley

[1] *Quart. Journ. Geol. Soc.*, vol. xxxi, 1875, p. 79.

a deposit of boulder clay, at an altitude of between 700 and 800 feet (present levels) which contains large blocks of Carboniferous limestone and boulders of Coal Measure sandstone. That deposit is supposed by Mr. Dixon to have been formed by the Irish Sea ice moving up the valley. From what has been said above, I think such an idea is quite untenable. Even if there had been in the neighbourhood a glacier having the necessary thickness it could not have moved up this valley, as it would have had to go for about a mile against a dead end and up a basal gradient of 1 in 40, as shown by Fig. 3, which is a longitudinal section of the valley. The mountain at A blocks up the end of the valley. It would also, probably, have to push back a descending glacier. The Irish Sea ice is supposed to have moved over the low-lying ground west of High Hows up the valley towards A.

The morainic matter lying at and near the foot of Ennerdale Lake, the gravel heaps of Cockhow, and the boulders on and near High Hows, are, I think, the work of floating ice, as suggested in my paper on the glacial deposits of West Cumberland, written in 1881.

A Marginal Modification of the Ballachulish Granite.

By Frederick Walker, B.A., Ph.D., Carnegie Research Scholar.

(PLATE XXVIII.)

THE Ballachulish "granite" has been well known to petrologists for many years through the writings of Sir J. J. H. Teall,[1] while more recently Mr. E. B. Bailey has described both the igneous rock and its associated contact phenomena in the *Geological Survey Memoir* for Sheet 53 [2] (Scotland).

In his account of the "granite" Mr. Bailey calls attention to the presence of a thin band of white granite between the normal "granite" and the Appin Quartzite at Rudh'a'Bhaid Bheithe (about 1 mile N.E. of Kentallen Pier), but no microscopical description is given. The writer proposes, therefore, to describe this marginal modification, as the rock presents several features of unusual interest.

The Normal Granite.—The normal "granite", which has been quarried extensively near Kentallen, is a basic hornblende-biotite-granodiorite in which the plagioclase (andesine) is usually three or four times more abundant than orthoclase. In a few sections one or two small crystals of pyroxene were observed enclosed in hornblende. Perhaps the most striking feature of the rock is the vast number of small xenoliths which occur throughout the mass. They are found in all stages of digestion, and consist,

[1] *British Petrography*, 1888, pp. 268, 325.

[2] *Mem. Geol. Survey*: *Ben Nevis and Glen Coe*, 1916, pp. 136–7, 165, 187 et seq.

apparently, of argillaceous schist. Portions of Ballachulish slate, with its characteristic pyrites cubes, may be often recognized, but some of the xenoliths have been so completely assimilated that dark basic patches in the "granite" alone indicate their former presence. Apart from these xenoliths the granodiorite is remarkably uniform in texture and composition.

The White Granite.—About 500 yards east of the Kentallen granite quarries is a trial quarry in which a splendid junction of the white granite with the Appin Quartzite is exposed (see plate). It is in this quarry that the white granite is best seen; it forms here a band, thirty feet in thickness, between the vertical quartzite strata and the normal grey granodiorite.

In the hand specimen the white granite is seen to be very poor in dark minerals. Specks of golden coloured mica may be made out on close examination, while pyrites is obviously abundant, though this mineral is almost completely absent from the normal grey rock. With the aid of a hand lens small crystals of pale green amphibole may be observed. The rock is of medium grain, is quite fresh, and is traversed by numerous thin veins of pegmatite and aplite, some of them finding their way into the adjacent quartzite.

Under the microscope, basic oligoclase is seen to be by far the most abundant constituent of the white granite. This felspar forms crystals of varying size which sometimes exhibit a rude idiomorphism. They also show lamellar twinning and zoning. The zoning, however, is not progressively acid from centre to margin, as is usual in plagioclase, but oscillates between soda-rich and lime-rich bands. The difference in composition of the zones is not great, and probably none of them lies outside oligoclase. Orthoclase and quartz come next in order of abundance, occurring in approximately equal proportions, while both are quite subordinate to the oligoclase. The orthoclase is always interstitial, but the quartz frequently penetrates plagioclase and sometimes even mica and amphibole. The ferro-magnesian minerals, which amount to less than 10 per cent of the rock, are quite abnormal in their characters. The mica is much paler than the biotite of the normal granodiorite, probably approaching phlogopite in composition. It is pleochroic in tints from golden yellow to a very pale straw colour. Though usually fresh it is sometimes altered to pale green chlorite. Never strikingly idiomorphic, it often encloses crystals of amphibole and sphene. The amphibole is generally quite colourless. It is optically negative, has extinction angles ($Z \wedge c$) up to 20°, while microchemical tests prove it to be aluminous. It may, therefore, be regarded as a variety of edenite—apparently a new edition to the list of pyrogenetic minerals. As a rule it is unaltered, but it occasionally weathers to a yellow chloritic substance. The crystals, which are rarely idiomorphic and for the most part quite small, tend to form clusters. Pyrites is moderately abundant, and was one of the first minerals to crystallize. It is occasionally

cupriferous. Small crystals of reddish sphene, showing strong pleochroism, are common, and often enclose tiny grains of deep brown rutile. The sphene is frequently idiomorphic, but is sometimes moulded on pyrites. Large hexagonal needles of apatite, often coloured blue or brown by minute inclusions, are sparsely distributed throughout the rock, while a few crystals of zircon may also be observed enclosed in mica. Xenoliths are entirely absent from the white granite.

Relations of the White Granite to the normal Granodiorite and Appin Quartzite.—It has been already stated that the white granite forms a thin band between the normal granodiorite and the Appin Quartzite, but the transition between the two igneous rocks is quite gradual.

Slightly over 30 feet in from the junction with the quartzite the normal granodiorite begins to show a falling off in the proportion of ferro-magnesian minerals, which becomes more marked as one passes outwards. Pyrites makes its appearance and increases in abundance as the quantity of ferro-magnesian minerals falls off. Microscopic examination shows that there is a gradual change of the green hornblende and biotite of the normal grey rock into the edenite and phlogopite of the white granite. Accompanying these changes is an increase in acidity on the part of the plagioclase. The transition is complete in about 6 feet.

The white granite shows a sharp junction with pronounced chilling against the vertical Appin Quartzite, and becomes extremely porphyritic towards the margin. The phenocrysts are oligoclase, green hornblende, and biotite, while the groundmass consists of small grains of quartz and orthoclase. The quartz crystallized out at a very early stage, very many small grains being enclosed in hornblende and biotite, and imparting a "worm-eaten" appearance to these minerals. The iron ore is magnetite.

As one passes inwards the rock is seen to lose its porphyritic character; the ferro-magnesian minerals show a gradual transition into edenite and phlogopite, while pyrites takes the place of magnetite exactly as in the transition described above. Although the ferro-magnesian minerals of the marginal rock are similar to those of the normal granodiorite, they are no more abundant than in the non-porphyritic white granite.

Origin of the White Granite.—After consideration of the evidence set forth above, the writer was led to the conclusion that there were two distinct episodes in the formation of the white granite:—

(1) Differentiation in situ of the normal granodiorite magma with the production of a more acid margin.

(2) An influx of sulphurous gases (probably hydrogen sulphide and sulphur vapour) into the white granite magma, leading to the formation of iron pyrites, and thus robbing the ferro-magnesian silicates of much of the iron which would otherwise have entered into their composition.

JUNCTION OF APPIN QUARTZITE AND GRANITE AT RUDH'A'BHAID BHEITHE, KENTALLEN, ARGYLLSHIRE.

[*To face p. 552.*

The gradual transition between the white granite and the normal granodiorite seems good evidence in favour of differentiation of the latter in situ. This differentiation was possibly due to a squeezing of more acid material to the margin, under pressure, at an early stage in the crystallization of the normal rock which, incidentally, shows distinct foliation in places. The chilled margin of the white granite no doubt represents the acid rock immediately after differentiation, for it contains no pyrites and had in all likelihood solidified before the advent of the sulphurous gases, thus escaping further modification. That the action of these gases ceased before crystallization of the non-porphyritic white granite was complete is shown by some of the pegmatite veins which traverse it. These veins, which seldom exceed one inch in thickness and consist of quartz, perthite, and normal black biotite, have enriched the edenite of the white granite in iron. Thus, on their fringes crystals of zoned amphibole with colourless centres and green margins may be observed, while the adjacent mica flakes also assume a deeper tinge. The veins of aplite, however, which are made up almost entirely of quartz and felspar, have had no effect on the surrounding rock. The one fact which does not admit of easy explanation is the very pronounced chilling of the white granite against the Appin Quartzite, for at all other junctions of the Ballachulish "granite" with schist examined by the writer, chilling is practically non-existent. The sharp chilled junction taken with the absence of xenoliths in the white granite does, however, rule out the possibility of the acid rock originating through assimilation of quartzite in situ.

Other Junctions of the Ballachulish Granite with Schists.—At other junctions of the Ballachulish "granite" with the Appin Quartzite the writer has found the normal granodiorite to persist almost up to the contact in an unchilled condition, the white granite being only found at Rudh'a'Bhaid Bheithe.

At the base of the Kentallen Pier there is a good junction of the granodiorite with the Appin Limestone, which is here very arenaceous. The igneous rock shows very little chilling against the schist, but an inch or two from the margin it becomes increasingly acid towards the contact, hornblende disappearing, while the orthoclase-plagioclase ratio rises sharply. Pegmatites, consisting almost entirely of felspar, occur in the schist near the junction. Similar phenomena are seen at a well-exposed junction between the granodiorite and the Leven Schists (phyllites) in a railway cutting a quarter of a mile east of Ballachulish Ferry station. A curious feature of the igneous rock close to the contact is local segregations of apatite needles. The phyllites have here been altered to a very beautiful hornfels containing abundant cordierite and sillimanite, as well as large zoned crystals of pink andalusite.

Analyses.	A.	B.
SiO_2	68·40	60·05
TiO_2	·28	·42
Al_2O_3	17·21	18·55
Fe_2O_3	traces	·93
FeO	·92	3·41
MgO	1·03	3·46
MnO	—	·16
(NiO, CoO)	—	—
CaO	3·05	5·44
Na_2O	4·48	3·84
K_2O	2·88	2·72
$H_2O + 105°$	·30	·35
$H_2O - 105°$	·12	·05
P_2O_5	·14	·29
CO_2	—	—
FeS_2	1·08	traces
	99·89	99·94 [1]

[1] Includes ZnO 0·27.

Norms.

	A.		B.
Quartz	23·10	Quartz	9·04
Orthoclase	17·02	Orthoclase	16·08
Albite	37·87	Albite	32·46
Anorthite	14·33	Anorthite	25·17
Corundum	1·42	Diopside	·11, ·10, ·04
Hypersthene	2·58, 1·23	Hypersthene	8·40, 5·03
Ilmenite	·53	Magnetite	1·35
Apatite	·31	Ilmenite	·79
Pyrite	1·08	Apatite	·63
H_2O, etc.	·42	H_2O, etc.	·67
	99·89		99·87

A. White Granite from trial quarry, Rudh'a'Bhaid Bheithe. Analyst, W. H. Herdsman.

B. Granodiorite from Kentallen quarries. Analyst, W. H. Herdsman.

The analyses of the normal granodiorite and of the white granite bring out clearly the differences of composition between the two rocks. The presence of zinc in the normal granodiorite is interesting and is undergoing further investigation. It was confirmed by photographs of the spectrum, for which the writer is indebted to Dr. E. B. Ludlam.

EXPLANATION OF PLATE XXVIII.

Junction of vertical Appin Quartzite and white granite at Rudh'a'Bhaid Bheithe. Note the veins of pegmatite and aplite in the quartzite.

REVIEWS.

GEOCHEMISCHE VERTEILUNGSGESETZE DER ELEMENTE. By V. M. GOLDSCHMIDT. Vidensk. Skrifter, I, Mat-Naturv Klasse, 1923, No. 2, pp. 17.

PART II: BEZIEHUNGEN ZWISCHEN DEN GEOCHEMISCHEN VERTEILUNGSGESETZEN UND DEM BAU DER ATOME. By the same. Ibid., 1924, No. 4, pp. 37, with one plate.

PART III: RÖNTGENSPEKTROGRAPHISCHE UNTERSUCHUNGEN ÜBER DIE VERTEILUNG DER SELTENEN ERDMETALLE IN MINERALEN. By V. M. GOLDSCHMIDT and L. THOMASSEN. Ibid., 1924, No. 5, pp. 58.

THE EVOLUTION AND DISINTEGRATION OF MATTER. By F. W. CLARKE. Professional Paper 132—D. U.S. Geol. Survey, pp. 51–86. 1924.

THE group of publications listed above are excellent examples of the wideness of the field now covered by geology and mineralogy. Dr. Clarke's contribution consists largely of an acute and well-reasoned criticism of the later ideas of the structure of matter and radioactive disintegration. His arguments are too technical and too complicated to be summarized here, but it should be noted that he lays great stress on the two-fold structure of the earth, regarding it, along with Wiechert, as consisting of a metallic core with a single silicate shell.

The other three publications may be regarded as to some extent a continuation of the same author's well-known memoir, *Der Stoffwechsel der Erde*. Professor Goldschmidt, in contrast to Wiechert and Clarke, regards the earth as a three-phase system, consisting of a nickel-iron core, a sulphide shell, and a silicate shell. This is founded mainly on metallurgical arguments, especially on the known very limited mutual solubility of sulphides and silicates, as shown in the common process of matte-smelting, and so strongly emphasized by Vogt.

The following is a literal but slightly abbreviated translation of the author's summary of the first of Professor Goldschmidt's memoirs cited above :—

> From the geochemical point of view the elements can be divided into four groups :
>
> Siderophil elements, concentrated in nickel-iron (e.g. cobalt).
>
> Chalkophil elements, concentrated in sulphide magmas (e.g. copper).
>
> Lithophil elements, concentrated in silicate magmas (e.g magnesium).
>
> Atmophil elements, concentrated in the atmosphere (e.g. argon).
>
> The separation into these four groups occurred to a great extent during the primary splitting of the globe or meteorites into phases, in accordance with the partition-coefficients of the elements in the several phases.
>
> A further separation of the elements was related to the continual physico-chemical differentiation of the lithosphere.
>
> The lithophil elements divide themselves into groups, depending on the course of magmatic differentiation. Their individual fates depend in the

first place on the extent of their isomorphism with the common rock-forming constituents in the crystalline state; the degree of isomorphism controls their partition-coefficients in the system solid-liquid.

The less common lithophil elements can be subdivided again into three groups.

Elements of the earliest crystallization, isomorphous with divalent iron and magnesium: e.g. chromium, vanadium, nickel.

Elements of the main crystallization, isomorphous with potassium, calcium, aluminium; e.g. rubidium, strontium.

Elements of the latest crystallization, slightly or not at all isomorphous with sodium, potassium, magnesium, calcium, aluminium, iron, and silicon: e.g. lithium, boron, niobium, thorium, lanthanum.

This scheme as here outlined, agrees very closely with the ideas set forth in recent publications as to the relations of magmatic ores to the different stages of crystallization, and to the degree of acidity of the silicate magmas: thus, chromium is always an early separation from ultrabasic magmas, nickel is found in peridotites (New Caledonia) and in norites (Norway and Canada), also as an early-separated partial magma (Sudbury). Most of the base-metals and gold belong to the main crystallization of large intrusions of intermediate and acid composition, while the third group, which is clearly related to the pegmatitic and pneumatolytic facies of intrusion, carries also tin, tungsten, molybdenum, and the rare-earth minerals. These form highly volatile compounds in the magma, rise to the top, and crystallize last.

The second part of Professor Goldschmidt's memoir deals with the relation of the laws of geochemical distribution to atomic structure. It is shown that the siderophil elements lie at the lowest points of the curve of atomic volumes, the lithophil elements mainly on the descending portions of the curve and the chalkophil elements on the ascending portions (atomic volume being plotted against atomic number): the degree of coincidence is very striking, there being few exceptions.

The third part of the memoir, written in collaboration with L. Thomassen, contains an account of investigations by means of X-ray spectrography of the distribution of the rare-earth metals in minerals, with an appendix on the natural conversion of crystalline minerals to the isotropic state, a phenomenon well-known in many radioactive substances. A large number of instances are given.

R. H. R.

THE EAST RIDING OF YORKSHIRE (with York). By BERNARD HOBSON, M.Sc., F.G.S. pp. xi + 174. Cambridge: At the University Press, 1924. Cloth, 4*s.* 6*d.* net.

THE latest addition to the Cambridge County Geographies displays all the good qualities which we have learnt to expect from its predecessors: sobriety of statement and judgment, accuracy, thoroughness of method combined with an equable balancing of such diverse interests as administration and ethnology, floral distribution and ecclesiastical architecture, etc. It is in no

spirit derogatory to the painstaking labours of Mr. Hobson, who, it will be remembered, contributed the manual on the West Riding also, that we venture to point out a few weaknesses, attributable in great measure to a striving for undue uniformity in all the books of this series. Too much space is allotted to the geology of the East Riding, which, for all the capital work that has been put into its investigation, is not of great moment or interest; 2½ pages are given over to tracing the complicated histories of the smaller railway concerns now all merged in the London and North-Eastern Railway Company, while virtually nothing is said about the present road-system—a subject not of very great importance when the series was originally planned; the two maps on the covers do not give some features and places of fair local importance, e.g. Stillingfleet Beck, Brough. In conclusion, we regret that the photograph-reproductions do not quite attain the high standard of the companion volumes and that in the list of towns and villages distances from better known places are given in but the fewest instances.

Geol. Survey of Nigeria: The Nigerian Coalfield, Section I, Enugu Area. By A. D. N. Bain, with appendices by R. Bullen Newton and A. C. Seward. Bull. No. 6, 1924, pp. 81, pls. 1–10, Geol. Map. Col. Scale 1 : 12,500.

THE Cretaceous and Tertiary infilling of the former Southern Nigeria Bay is remarkable for the extensive indications of petroleum it bears along its western seaboard, and for the more northern deposits of coal and lignite, which extend across the Niger from Enugu to beyond Asaba. With the happy exception of the Lutetian-Bartonian fauna of Ameki, the rocks of the southern province of Nigeria are unfortunately poor in fossils, and the exact age of the Enugu rocks is still a matter of doubt. The lower beds are undoubtedly Cretaceous, and there appears to be an upward passage to the Eocene.

This series is unconformably overlain by the Benin Sands. It is noteworthy in passing that the author attributes a continental origin to the latter series in the district under discussion. This may be, but the reviewer strongly dissents from such a suggestion in regard to the beds to the south and west. Of the older rocks the lowest group alone is marine, the remainder estuarine and freshwater; they are but slightly disturbed and dip at low angles to the W.N.W. Sections are given on "Topography", "Places of Interest near Enugu", and on "The Coal".

The last is to some extent supplementary to the Miscellaneous Colonial Office Reports and the Imperial Institute publications, and it is interesting to note that for 1922 the output was 110,785 tons, at a cost of winning of 2*s*. per ton, and a selling price (in 1923) of 10*s*. per ton.

As usual in these publications the plates are excellent.

J. P.

ELEMENTARY CRYSTALLOGRAPHY. By J. W. EVANS, D.Sc., F.R.S., F.G.S., and G. M. DAVIES, M.Sc., F.G.S. pp. 131, with 181 illustrations.

THIS volume is "written primarily for students of Geology and Mineralogy, and also as an introduction to Crystallography for chemists and physicists". The conceptions of planes, axes and centre of symmetry are clearly demonstrated, and the use of a set of axes in determining the position of crystal faces explained. This serves to introduce the crystal-systems and the notation of indices due to Miller. Goniometers and their use in crystal measurement are described and also the principles involved in stereographic and gnomonic projections. The omission of a more detailed treatment of the stereographic projection is to be regretted on account of its great importance in calculations of angles, etc., and in conveniently representing the results of crystal measurement. In the systematic description of the systems of symmetry, the orthorhombic is taken first, and its various forms and their mode of combination given. Under the heading of practical work, minerals crystallizing in this class are illustrated by accurate drawings and the axial ratios, habit, forms, etc., enumerated. This feature is continued throughout the book, and it is to be noted that these sections are very useful, serving to introduce the student of crystallography to mineralogy, and familiarize him with the appearance of the more important minerals. The tetragonal system is followed by the cubic, the holohedral class being first described. The introduction of face-symbols of the form $h_1\ h_2\ h_3$ instead of the usual h k l, is however to be deprecated, as being unnecessarily confusing. The cubic system is completed by a description of the tetrahedrite and pyrite classes. The holohedral class of the hexagonal system is illustrated by the symmetry of beryl, and this is succeeded by the trigonal classes as represented by calcite, tourmaline, and quartz. Next we have a very comprehensive chapter on twin-crystals, concluded by a table of the chief natural twins, with their twinning planes and planes of composition. Finally, the thirty-two classes of symmetry are summarized and concisely expressed by a table in which are included the particulars of each class; e.g. symbol (according to the notation described in the chapter), a substance crystallizing in it, and the number of faces in the general form.

W. A. WOOSTER.

OBSERVATIONS SUR DES TURRITELLES FIGURÉES PAR F. W. HARMER, DANS SON MÉMOIRE "THE PLIOCENE MOLLUSCA". By L. GUILLAUME. *Bull. Soc. Linn. Norm.*, ser. 7, vol. 7, pp. 55. 1924.

OF the 17 species of *Turritella* recorded by Harmer from the Pliocene of England 6 were regarded by him as characteristic of the Mediterranean Neogene, viz.:—*T. vermicularis* Br., *T.*

bicarinata Eichw., *T. marginata* Br., *T. tornata* Br., *T. decipiens* Mts., *T. turris* Bast. M. Guillaume doubts the occurrence of these southern forms in England. He regards the forms referred to *T. vermicularis* and *T. bicarinata* as probably variants of *T. incrassata* Sow.; the resemblance is believed to be due to convergence in the ornamentation, but the distinction is seen in the form of the striæ of growth.

Bristol Geology and Geography. By S. H. Reynolds. pp. 1–96, with 33 text-figures. Arrowsmith, Bristol. Price 2*s*. net.

BRISTOL is fortunate in being the centre of a district where the relation of the surface features to the underground geology can be so readily studied; nevertheless, the subject is sufficiently complicated to make it difficult of comprehension for those whose geological knowledge is somewhat limited. Hence this admirable little book will be warmly welcomed by many. Whilst largely based upon the author's *Geological Handbook* for the same district, it differs totally in plan, being treated by *areas* rather than by excursions, and the features of geographical interest and importance are specially indicated. It is illustrated by very clear plans and diagrams, and the publishers are to be warmly congratulated upon producing so excellent a guide at so reasonable a price.

G. L. E.

REPORTS AND PROCEEDINGS.

Mineralogical Society.

4th November.

Dr. M. S. Krishnan: Note on Cordierite in a Cordierite-gneiss from Madura District, Madras, India.

Optically positive cordierite occurs in an Archaean gneiss produced by the metamorphism of biotite-gneiss by an intrusive tongue of charnockite. The associated rocks are crystalline limestones (with lime-silicate minerals) and gneisses containing felspars, garnet, sillimanite, biotite, and titanoferrite. Cordierite from two other localities in Peninsular India (Vizagapatam and Travancore) is also known to be optically positive. This positive character is suggested to be due to the isomorphous replacement of MgO by FeO, as in the rhombic pyroxenes, olivines, etc.

Dr. A. Brammall: Lime as a constituent of certain important rock-forming minerals: its behaviour relative to that of other bases of RO type.

A review of the facts governing the extent to which RO-bases replace each other in rock-forming minerals, special reference being made to the antipathetic relationship between lime and magnesia as constituents of the same simple molecule.

Dr. L. J. Spencer: An inclusion of magnetite in diamond.

A minute black fragment (about 1 mg.) taken from a cavity in a diamond from Bultfontein mine, Kimberley, was definitely identified as magnetite. Black inclusions and spots are of common occurrence in diamond, but usually they are non-magnetic and therefore not magnetite.

Dr. L. J. Spencer: Biographical notices of mineralogists recently deceased (second series).

Notices of fifty-five English and foreign mineralogists. The average age of 303 lives (since 1876) is 64 years, and a curve shows a highest point at 74 years. The greatest age was attained by F. E. Naumann (1798–1895), the German crystallographer.

A. Russell: A notice of the occurrence of native arsenic in Cornwall (with analysis by Dr. H. F. Harwood); of bismuthinite at Shap, Westmorland; and of smaltite and niccolite at the Coniston Mine, Lancashire.

CORRESPONDENCE.

DIBUNOPHYLLUM θ VAUGHAN RENAMED *D. BOURTONENSE.*

Sir,—In the paper on "The Carboniferous Succession in the Settle District" published in the August number of the *Quarterly Journal of the Geological Society*, the name *Dibunophyllum vaughani* is suggested to replace *Dibunophyllum θ* Vaughan; see pp. 213, 259, 260, and plate xvi, figs. 5*a* and 5*b*. This name, however, has been already employed by Dr. Salée for another species of *Dibunophyllum* in his work on the Clisiophyllids published in 1913 in the *Mémoires de l'Institut Géologique de l'Université de Louvain*, so that the name is preoccupied. We therefore suggest "*bourtonense*" for the specific name of the form hitherto known as *Dibunophyllum θ*, the type specimen described by the late Dr. Vaughan, now in the British Museum (Nat. Hist.), having been obtained at Flax Bourton, near Bristol.

E. J. Garwood.
E. Goodyear.

INDEX.

ABSTRACTS, Geological, T. Sheppard, 240.
Actinodonta mendipensis sp. nov., 27.
Age of the Hirnant Beds, O. T. Jones, 283.
Allan, D. A., Geological Excursions of Brit. Association, 186.
Allopalladium from British Guiana, L. J. Spencer, 335.
Ammonites of the Speeton Clay, L. F. Spath, 73.
Ammonoidea of the Gault, L. F. Spath, 378.
Ancient Hunters and their Modern Representatives, W. J. Sollas, 429.
Andrews, C. W., Obituary notice of, 479.
— — Phosphate Deposits, Nigeria, 475.
Anorthoclase Xenocrysts in Scottish Rocks, V. A. Eyles, 471.
Anthology of Scientific Verse, C. E. Ruby, 336.
Anthracite, S. Wales, Micropetrology of, A. Stuart, 360.
Antillocaprina occidentalis gen. nov., 392, 407.
Antiquarian Notes, Upper Thames Valley, Lord Wyfold, 240.
Archæology of the Cambridge Region, C. Fox, 280.
Arsenic, native, occurrence in Cornwall, A. Russell, 560.
Arthropods, Fossil, from the Tyne Coalfield, E. L. Gill, 455.
Aru Islands, Fossil Echinoidea from, Ethel D. Currie, 52.
— — Geology of, J. W. Gregory, 52.
— — Late Kainozoic Pelecypoda from, L. R. Cox, 52.
Autobiography of Sir Archibald Geikie, 515.
Avonian of Cannington Park, Somerset, F. S. Wallis, 218.

BAILEY, E. B., Desert Shores of the Chalk Seas, 102.
Bain, A. D. N., Enugu Area of the Nigerian Coalfield, 557.
Ballachulish Granite, Marginal Modification of, F. Walker, 550.
Banton, J. T., Gravels of the Great Ouse Basin, 328.
Base of the Devonian, L. D. Stamp, 45, 351.
Bather, F. A., Shell of *Cornulites*, 96.
Belaiew, N. T., Widmanstätten structure in meteorites and terrestrial alloys, 95.
Bezanconia woodsi sp. nov., 13, 19.
Bi-axial crystals, L. R. Wilberforce, 95.
Biradiolites coryi sp. nov., 392, 401.
Biradiolites minhoensis sp. nov., 392, 402.
Biradiolites jamaicensis sp. nov., 392, 404.
Biradiolites mooretownensis sp. nov., 392, 404.
Biradiolitis rudissimus sp. nov., 392, 402.
Biradiolitis semiannulosus sp. nov., 392, 401.
Biradiolites (?) *subcancellatus* sp. nov., 392, 403.
Blue Lias of Devon-Dorset Coast, W. D. Lang, 183.
Bonney, Rev. T. G., Death of, 1.
— — Obituary notice of, 49.
Boswell, P. G. H., Faunal Relations, Crag Deposits, Suffolk, 379.
— — Petrography, Sands of the Upper Lias, 246.
Boule, Marcellin, Fossil Men, 171.
Bournonia barretti sp. nov., 392, 405.
Brammall, A., Gold and Silver in Dartmoor Granite, 184.
— — Lime as a constituent of important rock-forming minerals, 559.
Bristol Geology and Geography, S. H. Reynolds, 559.
British Virgin Islands, Geology of, K. W. Earle, 339.
Brockram and Associated Rocks, W. Cumberland, B. Smith, 289.
Brooks, C. E. P., Evolution of Climate, 177.
Brown, C. B., Effects of Wind and Sun in the Desert of Tumbez, Peru, 337.
Bubnoff, S. von., Coalfields of Russia and Siberia, 92.
Buckley, H. E., Optical properties of Seignette Salts, 94.
Bushveld Igneous Complex, Transvaal, R. A. Daly and G. A. F. Molengraaff, 333.

CALLIPTYCHOCERAS gen. nov. 88.
Campbell, J. Morrow, Lateritoid in Northern Rhodesia, 47.

Camptophyllia eltringhami gen. et sp. nov., 457, 467.
Camptophyllia fallax gen. et sp. nov., 457, 469.
Carbonaceous Shale of Jamaica, C. T. Trechmann, 2
Carboniferous Coral, a new Genus of, A. E. Clark, 416.
Cels, A., Evolution Géologique de la Terre, 331.
Chalk Seas, Desert Shores of the, E. B. Bailey, 102.
Challinor, J., "Farey's Grit," 423.
Chapman, F., Concretionary Limestones and Pebbles from Lake Omeo, 43.
— — Fossil Alga forming Opal Nodules, 93.
Cheirobelus gen. nov., 414.
China, Geological Society, 91.
— — — — Bulletin of, 472.
Chlorite from Bernstein, Austria, W. C. Smith and G. T. Prior, 335.
Clark, A. E., *Heptaphyllum*, New Genus of Carboniferous Coral, 416.
Clarke, F. W., Evolution and Disintegration of Matter, 555.
Climate, Evolution of, C. E. P. Brooks, 177.
— — Problem in Geology, W. Ramsay, 152.
Climatic Changes, E. Huntington and S. S. Visher, 331.
Coalfields of Russia and Siberia, S. von Bubnoff, 92.
Coal Measure Arthropods, from Northumberland, E. L. Gill, 455.
Coastal Geology, Fifeshire, S. R. Kirk, 186.
Cole, Grenville A. J., Obituary notice of, 285.
Comagmatic Regions and the Wegener Hypothesis, H. S. Washington, 180.
Concretionary Limestones and Pebbles from Lake Omeo, F. Chapman, 43.
Coniston Fells, Glaciation of the, J. E. Marr, 264.
Coniston Limestone, Unconformable Base of the, B. Smith, 163.
Continents separated by Fission, W. H. Pickering, 31.
Copper Ores, Cornwall and Devon, H. Dewey, 43.
Coralliochama radiolitiformis sp. nov., 392, 406.
Cordierite from Madura District, India, M. S. Krishnan, 559.
Cornish Veinstones, E. H. Davison, 225.
Cornulites, Shell of, F. A. Bather, 96.
Correlation of Chemistry and Geology, J. A. Watson, 524.
Corrour and the Moor of Rannoch, 174.
Cox, A. H., Pre-glacial Rock-surface, Rhiwbina, near Cardiff, 241.
Cox, L. R., Late Kainozoic Pelecypoda from the Aru Islands, 52.
Cretaceous Belemnites, Dimitobelidae, a new family of, F. W. Whitehouse, 410.
Cretaceous Limestone of Jamaica, C. T. Trechmann, 385.
Crystalline Metamorphic Rocks of S.W. Togoland, T. Robertson, 116.
Crystallography, Elementary, J. W. Evans and G. M. Davies, 558.
Cumberland, Supposed Glacial-lake in, J. D. Kendall, 541.
Currie, Ethel D., Fossil Echinoidea from the Aru Islands, 52.

DADOXYLON type of fossil wood from Essex, W. N. Edwards, 538.
D. bourtonense, formerly *Dibunophyllum θ* Vaughan, E. J. Garwood and E. Goodyear, 560.
Dall, W. H., Fossiliferous Strata on Galapagos Island, 428.
Daly, R. A., Bushveld Igneous Complex, Transvaal, 333.
Davies, A. M., Local Geology, 38.
— — Type Specimens, 527.
Davies, G. M., Elementary Crystallography, 558.
Davison, E. H., Cornish Veinstones, 225.
— — Some Cornish Veinstones, 523.
Day, T. C., River Deposit filling Cave at Blackford Hill, 185.
— — Two unrecorded Volcanic Vents, N. Berwick, 93.
Desert of Tumbez, Peru, Effects of Wind and Sun, C. B. Brown, 337.
Desert Shores of the Chalk Seas, E. B. Bailey, 102.
Devonian, Base of the, L. D. Stamp, 351.
Dewey, H., Copper Ores, Cornwall and Devon, 43.
— — Tungsten and Manganese Ores, 181.
Diatomaceous Earth in Egypt, F. W. Moon, 143.
Dibunophyllum θ Vaughan, renamed *D. bourtonense*, E. J. Garwood and E. Goodyear, 560.
Dimitobelidae, new family of Cre-

taceous Belemnites, F. W. Whitehouse, 410
Dimitobelus gen. nov., 412.
Dines, H. G., Tungsten and Manganese Ores, 181.
Dixey, F., Mineral Resources of Nyasaland, 522.
Double, I. S., Petrography, Later Tertiary Deposits, E. of England, 380.
Dumortierite in British Rocks, W. Mackie, 185.

EARLE, K. W., Geology of the British Virgin Islands, 339.
Echinoidea, Fossil, from Aru Islands, Ethel D. Currie, 52.
Echinoidea, Fossil, from Jamaica, New Collection of, H. L. Hawkins, 312.
Eckford, R. J. A., Glacial Overflow Channel, Peeblesshire, 523.
Edinburgh Geological Society, 93, 138, 184, 523.
Edmondia punctatella (Jones), in Fife, D. Haldane, 524.
Edwards, W. N., Fossil wood from Essex, 538.
Effects of Wind and Sun in the Desert of Tumbez, Peru, C. B. Brown, 337.
Ennos, F. R., Stilpnomelane from N. Wales, 96.
Eocene Cycles of Sedimentation, A. K. Wells and S. W. Wooldridge, 188.
— — L. Dudley Stamp, 98, 336.
Eophrynus pococki sp. nov., 457, 459.
Euclase and Platinum from diamond washing, British Guiana, L. J. Spencer, 94.
Evans, J. W., Elementary Crystallography, 558.
Evolution and Disintegration of Matter, F. W. Clarke, 555.
Evolution Géologique de la Terre, A. Cels, 331.
Evolution of Man, G. E. Smith, 473.
Excursions, Geological, of Brit. Association, D. A. Allan, 186.
Eyles, V. A., Scottish Rocks with Anorthoclase Xenocrysts, 471.

FACIES of Metamorphic Rocks, C. E. Tilley, 167.
"Farey's Grit," J. Challinor, 423.
Faunal Relations, Crag Deposits, Suffolk, P. G. H. Boswell, 379.
Faunus (*Melanatria*) *vulcaniformis* sp. nov., 10, 19.
Findhorn and Strath-Nairn, Lower, 174.
Fitton, Dr. W. H., Memoirs, T. Sheppard, 192.
Flett, J. S., Peléan Eruptions, 525.
Flint Flakings of the Weybourne Crag, S. H. Warren, 309.
Flint Spheres, called "Cannon Shots", from Norfolk, F. N. Haward, 183.
Flinty Crush Rocks, Observations on, T. J. Jehu, 140.
Floods and River Drainage, R. Weatherall, 360.
Fossil Men, Marcellin Boule, 171.
Fossil Wood from Tiptree, Essex, W. N. Edwards, 538.
Fossiliferous Strata on Galapagos Island, W. H. Dall, 428.
Fossils from the Midland Coalfields, R. D. Vernon, 45.
Fossils, New Ordovician and Silurian, F. R. Cowper Reed, 25.
Fox, C., Archæology of the Cambridge Region, 280.
Frost Action in Superficial Deposits, Iceland, L. Hawkes, 509.

GALAPAGOS Island, Fossiliferous Strata on, W. H. Dall, 428.
Garwood, E. J., *Dibunophyllum θ* Vaughan, renamed *D. bourtonense*, 560.
Geikie, Sir Archibald, Autobiography of, 515; death of, 530.
Geochemistry, 555.
Geodynamic Phenomena, Origin of, C. G. S. Sandberg, 482.
Geological Section of Roade Cutting, B. Thompson, 210.
Geological Society, Award of Medals, 97.
— — Election of Officers, 97.
— — Club, Centenary anniversary dinner, 530.
Geological Survey, Summary of Progress, for 1922, 182.
Geologists' Association, 183, 379.
Geology in the Service of Man, W. W. Watts, 493, 531.
Geology and Petrology of Rockall, G. W. Tyrrell, 19.
Gill, E. L., Fossil Arthropods from the Tyne Coalfields, 455.
Glacial Overflow Channel, Peeblesshire, R. J. A. Eckford and W. Manson, 523.
Glaciation of the Coniston Fells, J. E. Marr, 264.
Glacier-lake, Supposed, in W. Cumberland, J. D. Kendall, 541

Gold Deposits, Western Australia, A. Gibb Maitland, 42.
Gold and Silver in Dartmoor granite, A. Brammall and H. F. Harwood, 184.
Goldschmidt, V. M., Distribution of Elements, 555.
Goniopygus supremus sp. nov., 312, 314.
Goodyear, E., *Dibunophyllum θ* Vaughan, renamed *D. bourtonense*, 560.
Granitic Intrusions in S.E. Scotland, F. Walker, 186.
Gravels from Brain Valley, Essex, Pliocene Age of, J. W. Gregory, 539.
Gravels of the Great Ouse Basin, J. T. Banton, 328.
Greenland, Mineral Resources of, S. H. Hall, 137.
Greenly, E., Hanging Valleys of Nant-Ffrancon, 189.
Gregory, J. W., Geology of the Aru Islands, 52.
— — Pliocene Age of Brain Valley Gravels, 539.
Guillaume, L., *Turritella* recorded by F. W. Harmer, 558.
Gyroceras (?) *obliquistriatum* sp. nov., 26.

HALDANE, D., Note on discovery of *Edmondia punctatella* (Jones) in Fife, 524.
Hall, S. H., Mineral Resources of Greenland, 137.
Hallimond, A. F., Chemical Classification of the Mica group, 183.
Hanging Valleys of Nant-Ffrancon, E. Greenly, 189.
Harmer, F. W., Pliocene Mollusca of Great Britain, 378.
Harris, Stella W., Petrography, Triassic Sandstones of S.W. Lancashire, 187.
Harwood, H. F., Gold and Silver in Dartmoor granite, 184.
Hawkes, L., Frost Action in Superficial Deposits, Iceland, 509.
Hazzledine Warren's views on subsoil pressure-flaking of flints, R. D. Vernon, 43.
Hawaiian Islands, Petrology of, H. S. Washington, 179.
Haward, F. N., Flint Spheres from Norfolk, 183.
Hawkins, H. L. New Collection of Fossil Echinoidea from Jamaica, 312.
Hebertia simplex sp. nov., 312, 318.
Heptaphyllum gen. nov., 416.
Heptaphyllum gracile sp. nov., 417.
Heptaphyllum magnum sp. nov., 420.
Heptaphyllum, New Genus of Carboniferous Coral, A. E. Clark, 416.
Highgate Amber, G. C. Williamson, 192.
Historical Notes on Working of the Wardie Coal, D. Tait, 139.
Hopkins, P. E., Ontario Gold Deposits, 474.
Hallimond, A. F., Stilpnomelane from N. Wales, 96.
Hudson, B., East Riding of Yorkshire, 556.
Huntington, E., Climatic Changes, 331.
Huntly Gabbro Mass, Aberdeenshire, Xenoliths in, H. H. Read, 433.

ICELAND, Superficial Deposits, Frost action in, L. Hawkes, 509.
Igneous Intrusion and Deep Vein Filling, E. H. Davison, 225.
Igneous Rocks of the Torquay Promontory, W. G. Shannon, 193.
Isostatic Tendencies and Geodynamic Phenomena, C. G. S. Sandberg, 482.

JAMAICA, New Collection of Fossil Echinoidea from, H. L. Hawkins, 312.
Jones, O. T., Age of the Hirnant Beds, 283.
Jehu, T. J., Observations on Flinty Crush Rocks, 140.

KAINOZOIC Pelecypoda from the Aru Islands, L. R. Cox, 52.
Keeping, Henry, Obituary notice of, 140.
Kendall, J. D., Supposed Glacier-lake in W. Cumberland, 541.
Kimmeridge Clay, Zonal Nomenclature of, E. Neaverson, 145.
Kirk, S. R., Coastal Geology, Fifeshire, 186.
Kidston, R., Obituary notice of, 477.
Krishnan, M. S., Cordierite from Madura District, India, 559.

LAKE District, Quartz-porphyry from the, S. Melmore, 513.
Lamplugh, G. W., Concealed Mesozoic Rocks in Kent, 136.
— — Speeton Ammonites, 191.
Lang, W. D., Blue Lias of Devon-Dorset coast, 183.
— — Species Concept in Palaeontology, 526.

Lateritoid in Northern Rhodesia, J. Morrow Campbell, 47.
Lightfoot, B., Geology of Lomagundi District, S. Rhodesia, 522.
Lime as a constituent of important rock-forming minerals, A. Brammall, 559.
Linthia trechmanni sp. nov., 312, 319.
Liverpool Geological Society, 187, 381.
Local Geology, A. M. Davies, 38.

MACGREGOR, M., Millstone Grit, Central Coalfield, Scotland, 184.
Mackie, W., Dumortierite in British Rocks, 185.
Magnesian Limestone, Beds Underlying, H. C. Versey, 380.
Magnetite in diamond, an inclusion of, L. J. Spencer, 560.
Maitland, A. Gibb, Gold Deposits, Western Australia, 42.
Man and the Ice Age, W. J. Sollas, 190.
Manson, W., Glacial Overflow Channel, Peebles-shire, 523.
Marginal Modification of the Ballachulish Granite, F. Walker, 550.
Marine Triassic Shells, Singapore, R. B. Newton, 239.
Marr, J. E., Glaciation of the Coniston Fells, 264.
Maufe, H B., Geology of Lomagundi District, S. Rhodesia, 522.
Melmore, S., Quartz-porphyry from the Lake District, 513.
Merrett, E. A., Fossil Ostracods in Stratigraphy, 228.
Mesozoic Rocks in Kent, G. W. Lamplugh, 136.
Metalliferous Deposits, Geology of, R. H. Rastall, 38.
Metamorphic Rocks, Facies of, C. E. Tilley, 167.
Mica group, Chemical classification of, A. F. Hallimond, 183.
Microgranite from Westmorland, H. C. G. Vincent, 335.
Micropetrology of S. Wales Anthracite, A. Stuart, 360.
Minerals, X-ray investigations, 555.
Millstone Grit, Central Coalfield, Scotland, M. Macgregor, 184.
Mineralogical Society, 94, 183, 335, 559.
Molengraaff, G. A. F., Bushveld Igneous Complex, Transvaal, 333.
Mollusca of the Cretaceous Limestone, Jamaica, C. T. Trechmann, 385.
Molyneux, A. J. C., Geology of Lomagundi District, S. Rhodesia, 522.
Monchiquite Dyke in Lauderdale, F. Walker, 525.
Moon, F. W., Diatomaceous Earth in Egypt, 143.
Morgania mariensis sp. nov., 13, 19.

NADORITE in Cornwall, A. Russell, 95.
Natica mariensis sp. nov., 11, 19.
Neaverson, E., Zonal Nomenclature of the Upper Kimmeridge Clay, 145.
Neocomian and Aptian Ammonites of Speeton, L. F. Spath, 73.
Newton, R. B., Enugu Area of the Nigerian Coalfield, 557.
— — Marine Triassic Shells, Singapore, 239.
Nickel Ores, W. G. Rumbold, 92.
Nigerian Coalfield, Enugu Area, A. D. N. Bain, R. B. Newton, and A. C. Seward, 557.
Nomenclature of Rocks, H. C. Sargent, 384.
— — W. G. Shannon, 432.
— — A. K. Wells, 324, 528.
Non-ferrous Metals, N. M. Penzer, 282.
Nyasaland, Geol. Survey of, Mineral Resources, F. Dixey, 522.

OAKES, E. C., Pre-glacial Rock-surface, Rhiwbina near Cardiff, 241.
Obituaries: The Rev. Professor T. G. Bonney, 49; Henry Keeping, 140; Professor F. Omori, 141; Professor Grenville A. J. Cole, 285; Sir Jethro Justinian Harris Teall, 382; Dr. R. S. Woodward, 432; Robert Kidston, 477; Charles William Andrews, 479.
Octagoniceras gen. nov., 88.
Odontodiscoceras gen. nov., 88.
Omori, Professor F., Obituary notice of, 141.
Ontario Gold Deposits, P. E. Hopkins, 474.
Opal Nodules, N.S.W., Frederick Chapman, 93.
Ordovician and Silurian Fossils, New, F. R. Cowper Reed, 25.
Ore Magmas, J. E. Spurr, 90.
Ostracods, Fossil, in Stratigraphy, E. A. Merrett, 228.
Ouse Basin, Gravels of the, J. T. Banton, 328.

PALAEONTOGRAPHICAL Society, 378.
Palaeontology, Outlines of, H. H. Swinnerton, 334.
Palaeontology, Species-Conception, A. E. Trueman, 355.
Paraebarrettia sparcilirata gen. nov., 392, 395.
Pedology as a Branch of Geology, G. W. Robinson, 444.
Peléan Eruptions, J. S. Flett, 525.
Penmaenmawr Mountain, Petrology of, H. C. Sargent, 381.
Penzer, N. M., Non-ferrous Metals, 282.
Peratobelus gen. nov., 410.
Periaster sp. nov., 312, 319.
Perrett, F. W., Vesuvius, Eruption of, 1906, 519.
Petrography, Later Tertiary Deposits, E. of England, I. S. Double, 380.
Petrographic Expedition to Iceland 288.
Petrography of Torquay, W. G. Shannon, 193.
Petrography, Sands of the Upper Lias, P. G. H. Boswell, 246.
Petrography, Triassic Sandstones of S.W. Lancashire, Stella W. Harris, 187.
Phosphate Deposits, Nigeria, W. Russ and C. W. Andrews, 475.
Pickering, W. H., Separation of Continents by Fission, 31
Platinum in the Waterberg District, P.A. Wagner and T. G. Trevor, 238.
Pliocene Age of the Brain Valley Gravels, Essex, J. W. Gregory, 539.
Pliocene Mollusca of Great Britain, F. W. Harmer, 378.
Pre-glacial Rock-surface, Rhiwbina, near Cardiff, A. H. Cox and E. C. Oakes, 241.
Prior, G. T., Compact chlorite from Bernstein, Austria, 335.
Pseudoosterella subosterella gen. nov., 88.
Pyrazus matleyi sp. nov., 14, 19.

QUARTZ-PORPHYRY from the Lake District, S. Melmore, 513.

RAEBURN, C., Tinfields of Nassarawa, 378.
Raimondiceras gen. nov., 87.
Ramsay, W., Climate Problem in Geology, 152.
Rastall, R. H., Geology of Metalliferous Deposits, 38.
Read, H. H., Xenoliths in the Huntly Gabbro Mass, 433.
Reed, F. R. C., New Ordovician and Silurian Fossils, 25.
— — Shell of *Cornulites*, 48.
Relief Hypothesis to solve the Climate Problem, W. Ramsay, 152.
Revue de Géologie, 143.
Reynolds, S. H., Bristol Geology and Geography, 559.
Rhizophyllum(?) *tortworthense* sp. nov., 29.
Rhodesia, Guide to, 379.
Rhodesia, S., Geology of Lomagundi District, H. B. Maufe, B, Lightfoot, and the late A. J. C. Molyneux, 522.
Richmond Formation of Jamaica, C. T. Trechmann, 2.
Rift and Trough-Valleys, P. A. Wagner, 285.
River Drainage and Floods, R. Weatherall, 360.
River Deposit filling Cave at Blackford Hill, T. C. Day, 185.
Roade Cutting, Geology of, B. Thompson, 210.
Robertson, T., Crystalline Metamorphic Rocks of S.W. Togoland, 116.
Robinson, G. W., Pedology as a Branch of Geology, 444.
Roches district, N. Staffs, "Farey's Grit," J. Challinor, 423.
Rock-surface, Pre-glacial, near Cardiff, A. H. Cox and E. C. Oakes, 241.
Rockall, Geology and Petrography of, G. W. Tyrell, 19.
Rocks between Leith and Granton, D. Tait, 138.
Rocks, Nomenclature of, H. C. Sargent, 384; W. G. Shannon, 432; A. K. Wells, 324.
Ruby, C. E., Anthology of Scientific Verse, 336.
Rumbold, W. G., Nickel Ores, 92.
Russ, W., Phosphate Deposits, Nigeria, 475.
Russell, A., Nadorite in Cornwall, 95.
— — Occurrences of Native Arsenic in Cornwall, 560.
— — Topaz from Cornwall, 184.

SAMOA, Western, Geology of, J. A. Thomson, 473.
Sandberg, C. G. S., Isostatic Tendencies and Geodynamic Phenomena, 482.

Sands of the Upper Lias, Petrography, P. G. H. Boswell, 246.
Sargent, H. C., Nomenclature of Rocks, 384.
— — Petrology of the Penmaenmawr Mountain, 381.
Scottish Geological Survey, Memoirs of, 174.
Scottish Rocks bearing Anorthoclase Xenocrysts, V. A. Eyles, 471.
Scottish "Woodocrinus" Fauna, J. Wright, 270.
Sedimentary Petrography, Leipzig Mineralogical Society, 431.
Sedimentation, Eocene Cycles of, L. Dudley Stamp, 98.
— — Report of Committee on, W. H. Twenhofel, 521.
Seignette salts, optical properties of, H. E. Buckley, 94.
Separation of Continents by Fission, W. H. Pickering, 31.
Seward, A. C., Enugu Area of the Nigerian Coalfield, 557.
Shaftesbury, Geology of Country S. and W. of, H. J. Osborne White, 181.
Shannon, W. G., Nomenclature of Rocks, 432.
Shannon, W. G., Petrography of Torquay, 193.
Shell of *Cornulites*, F. R. C. Reed, 48.
Sheppard, T., Dr. W. H. Fitton's Memoirs, 192.
— — Geological Abstracts, 240.
Simmons, W. C., Geology of Wirral and Flintshire Coalfield, 37.
Smith, B., Geology of Wirral and Flintshire Coalfield, 37.
— — Unconformable Base of the Coniston Limestone, 163.
— — West Cumberland Brockram, 289.
Smith, G. E., Evolution of Man, 473.
Smith, W. Campbell, Compact chlorite from Bernstein, Austria, 335.
Société des Sciences, Lille, award of medals, 97.
Soil, the Study of the, G. W. Robinson, 444.
Sollas, W. J., Ancient Hunters and their Modern Representatives, 429.
— — Man and the Ice Age, 190.
Somerset, Avonian of Cannington Park, F. S. Wallis, 218.
Spath, L. F., Ammonites of the Speeton Clay, 73.
— — Ammonoidea of the Gault, 378.
Species Concept in Palaeontology, W. D. Lang, 526.
Species Concept in Palaeontology, A. E. Trueman, 355.
Speeton Ammonites, G. W. Lamplugh, 191.
Spencer, L. J., Allopalladium from British Guiana, 335.
— — Biographical notices of recently deceased Mineralogists, 560.
— — Euclase and Platinum from diamond washing, British Guiana, 94.
— — Inclusion of Magnetite in Diamond, 560.
Spurr, J. E., Ore Magmas, 90.
Stamp, L. D., Base of the Devonian, 45, 351.
— — Eocene Cycles of Sedimentation, 98, 336.
Stratigraphical Research, Use of Fossil Ostracods in, E. A. Merrett, 228.
Stilpnomelane from N. Wales, A. F. Hallimond and F. R. Ennos, 96.
Stuart, A., Micropetrology of S. Wales Anthracite, 360.
Swinnerton, H. H., Outlines of Palaeontology, 334.

TAIT, D., Historical Notes on Working of the Wardie Coal, 139.
— — Rocks between Leith and Grantham, 138.
Tanganyika Territory, Geological Survey of, E. O. Teale, 41.
Teale, E. O., Geological Survey of Tanganyika Territory, 41.
Teall Collection, 481.
Teall, Sir J. J. Harris, Obituary of, 382.
Tetrabelus gen. nov., 413.
Thompson, B., Geology of Roade Cutting, 210.
Thomson, J. A., Geology of Western Samoa, 473.
Tilley, C. E., Appointment as Demonstrator of Petrology, Cambridge, 1.
— — Facies of Metamorphic Rocks, 167.
Tinfields of Nassarawa, C. Raeburn, 378.
Titanosarcolites gigantea gen. nov., 392, 397.
Togoland, Crystalline Metamorphic Rocks, T. Robertson, 116.
Topaz from Cornwall, A. Russell, 184.
Trechmann, C. T., Carbonaceous Shale of Jamaica, 2.
— — Cretaceous Limestone of Jamaica, 385.

Trevor, T. G., Platinum in the Waterberg District, 238.
Trueman, A. E., Species-Concept in Palaeontology, 355.
Tryblidium girvanense sp. nov., 25.
Tryblidium kilbridense sp. nov., 26.
Tungsten and Manganese Ores, H. Dewey and H. G. Dines, 181.
Turritella recorded by F. W. Harmer, L. Guillaume, 558.
Twenhofel, W. H., Report of Committee on Sedimentation, 521.
Type-Specimens, A. M. Davies, 527.
Tyrrell, G. W., Geology and Petrography of Rockall, 19.
— — Volcanic Geology, East Fife, 142.

UNCONFORMABLE Base of the Coniston Limestone, B. Smith, 163.

VEINSTONES, Cornish, E. H. Davison, 523.
Versey, H. C., Beds Underlying the Magnesian Limestone, 380.
Vernon, R. D., Fossils from the Midland Coalfields, 45.
— — Hazzledine Warren's views on subsoil pressure-flaking of flints, 43.
Vesuvius Eruption of 1906, F. W. Perrett, 519.
Vincent, H. C. G., Microgranite from Westmorland, 335.
Virgin Islands, Geology of, K. W. Earle, 339.
Visher, S. S., Climatic Changes, 331.
Volcanic Geology, East Fife, G. W. Tyrrell, 142.
Volcanic Vents, Two unrecorded, N. Berwick, T. Cuthbert Day, 93.

WAGNER, P. A., Rift and Trough Valleys, 285.
— — Platinum in the Waterberg District, 238.
Walker, F., Granitic Intrusions in S.E. Scotland, 186.
— — Marginal Modification of the Ballachulish Granite, 550.
— — A Monchiquite Dyke in Lauderdale, 525.
Wallis, F. S., Avonian of Cannington Park, Somerset, 218.
Warren, S. H., Flint Flakings of the Weybourne Crag, 309.
Washington, H. S., Comagmatic Regions and the Wegener Hypothesis, 180.
Washington, H. S., Hawaiian Islands, Petrology of, 179.
Watson, J. A., Correlation of Chemistry and Geology, 524.
Watts, W. W., Geology in the Service of Man, 493, 531.
Weatherall, R., River Drainage and Floods, 360.
Wedd, C. B., Geology of Wirral and Flintshire Coalfield, 37.
Wells, A. K., Eocene Cycles of Sedimentation, 188.
— — Nomenclature of Rocks, 324, 528.
West Cumberland Brockram, B. Smith, 289.
Weybourne Crag, Flint Flakings, S. H. Warren, 309.
White, H. J. Osborne, Geology of Country S. and W. of Shaftesbury, 181.
Whitehouse, F. W., Dimitobelidae, new family of Cretaceous Belemnites, 410.
Widmanstätten structure in meteorites and terrestrial alloys, N. T. Belaiew, 95.
Wilberforce, L. R., Bi-axial Crystals, 95.
Williamson, G. C., Highgate Amber, 192.
Wirral and Flintshire Coalfield, C. B. Wedd, B. Smith, W. C. Simmons, and D. A. Wray, 37.
"Woodocrinus" Fauna from the Scottish Border, J. Wright, 270.
Woodward, Dr. R. S., Obituary notice of, 432.
Wooldridge, S. W., Eocene Cycles of Sedimentation, 188.
Wray, D. A., Geology of Wirral and Flintshire Coalfield, 37.
Wright, J., "Woodocrinus" Fauna from the Scottish Border, 270.
Wyfold, Lord, Antiquarian Notes, Upper Thames Valley, 240.

XENOLITHS in the Contaminated Rocks, Huntly, Aberdeenshire, H. H. Read, 433.

YORKSHIRE, East Riding of, B. Hudson, 556.
Yorkshire Geological Society, 380.

ZONAL Nomenclature of the Upper Kimmeridge Clay, E. Neaveson, 145.

Stephen Austin and Sons, Ltd., Printers, Hertford.

No. 726. Vol. LXI of Whole Series. Price 2s. 6d.

The Geological Magazine

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

FOUNDED IN 1864, BY THE LATE DR. HENRY WOODWARD, F.R.S.

EDITOR — R. H. RASTALL, Sc.D., M.INST.M.M.

ASSISTED BY

PROF. W. S. BOULTON, D.Sc.
PROF. J. W. GREGORY, D.Sc., F.R.S.
F. H. HATCH, PH.D., M.INST.M.M.
SIR T. H. HOLLAND, K.C.S.I., F.R.S.
PROF. J. E. MARR, Sc.D., F.R.S.
PROF. W. W. WATTS, Sc.D., F.R.S.
HENRY WOODS, M.A., F.R.S.
SIR A. SMITH WOODWARD, LL.D., F.R.S.

LIBRARY OF THE UNIVERSITY OF WISCONSIN

DECEMBER, 1924.

CONTENTS:—

	Page
EDITORIAL NOTES	529
ORIGINAL ARTICLES.	
Geology in the Service of Man. By Professor W. W. WATTS. (*Concluded.*)	531
Fossil Wood from Tiptree, Essex. By W. N. EDWARDS	538
The Age of the Brain Valley Gravels. By Professor J. W. GREGORY	539
On a supposed Glacier-lake in West Cumberland. By J. D. KENDALL. (With 3 Figures.)	541
A Marginal Modification of the Ballachulish Granite. By F. WALKER. (With Plate XXVIII.)	550
REVIEWS.	Page
The Elements in Geology	555
East Yorkshire	556
Geology of Nigeria	557
Elementary Crystallography	558
Pliocene Species of *Turritella*	558
Geology of Bristol	559
REPORTS AND PROCEEDINGS.	
Mineralogical Society	559
CORRESPONDENCE.	
E. J. Garwood and E. Goodyear	560
INDEX, etc	561

LONDON: DULAU & CO., LTD., 34-36 MARGARET STREET, CAVENDISH SQUARE, W.1.

Subscriptions (30s. net) for 1925 are now due; please remit as early as possible to avoid delay in the dispatch of the next number. Cloth Cases for Binding may be had, price 2s. 6d. net.

From MURBY'S GEOLOGICAL SERIES

The Latest Book in the Series.

ELEMENTARY CRYSTALLOGRAPHY.

By J. W. EVANS, D.Sc., F.R.S., F.G.S., President of the Geological Society, and G. M. DAVIES, M.Sc., F.G.S.

It contains 181 Diagrams. 9*s*. 6*d*. net.

"Up to the time of the publication of this volume, it was almost impossible for a student to obtain a comprehensive idea of crystallography without first having to consult the more advanced text-books on the subject, a task which is especially tedious for a beginner. In 'Elementary Crystallography,' however, the subject is presented in a concise and scientific manner, simple and convincing diagrams are plentiful throughout the text, and each section of the book is followed by well-chosen suggestions for practical work."—*Naturalist.*

Local Geology. A Guide to the Sources of Information. 1*s*. net. By A. MORLEY DAVIES, D. Sc., F. R. G. S., F.G.S.

"A remarkably useful booklet, likely to prove of the greatest benefit to teachers of Physical Geography."—*A.M.A.*

An Introduction to Palæontology. By A. MORLEY DAVIES, A.R.C.S., D.Sc., F.G.S., Lecturer on Palæontology, Imperial College of Science. 12*s*.6*d*. net. Postage 6*d*.

"Dr. Davies' book should be an ever present help to all working palæontologists."—*Nature.*

Graphical and Tabular Methods in Crystallography. By T. V. BARKER, University Lecturer in Chemical Crystallography, Oxford. 14*s*. net.

"The book is based on sound practical lines."—*Science Progress.*

ANNOUNCEMENTS.

Imper. 8vo. With Text Figures and Map. Price 8*s*.6*d*. net. (*Ready Dec.*)

A Handbook of the Geology of Ireland. By the late Prof. G. A. J. COLE and T. HALLISSY. Preface by Dr. J. W. EVANS, President of the Geological Society.

This volume is based on the late Professor Cole's contributions to "The Handbook of Regional Geology," published some years ago in Heidelberg. The copyright was purchased from the German publishers, and it was decided to issue a revised edition in two volumes, of which one should be devoted to Ireland.

Crown 8vo. With 61 Text Figures. Price 7*s*. 6*d*. net. (*Ready Dec.*)

Useful Aspects of Geology. By S. J. SHAND, D.Sc., Ph.D., F.G.S., Prof. of Geology in Stellenbosch Univ.

A book for those who have never picked up any systematic knowledge of geology, and who are interested in one or other of the many undertakings that depend for their success upon the application of geology.

It gives an account of the various ways in which a knowledge of geology can be turned to use, and shows where to go for fuller information.

Petrographic Methods and Calculations. By ARTHUR HOLMES, D. Sc., A. R. C. S., D.I.C., F.G.S. 31*s*.6*d*. net (in one volume).

Also in Three Parts.

Part I—Specific Gravity. Separation and Determination of Minerals, Detrital Sediment.- 15*s*. 6*d*. net.

Part II—The Study of Thin Sections. 10*s*.6*d*. net.

Part III—Chemical Methods and Calculations. 8*s*. 6*d*. net.

A reasonably complete dictionary recording the customary meanings of petrological terms.

The Nomenclature of Petrology. By ARTHUR HOLMES, D. Sc., A. R. C. S., D.I.C., F.G.S. 12*s*.6*d*. net. Postage 4*d*.

"This book comes as a godsend, both to the economic geologist and the student."—*Mining Magazine.*

A closely packed manual of Stratigraphical Geology.

An Introduction to Stratigraphy (British Isles). By L. DUDLEY STAMP, B.A., D.Sc., A.K.C., F.G.S. 10*s*. net. Postage 5*d*.

"This is a distinctly original work that will be of service to very many students."—*Nature.*

An Introduction to Sedimentary Petrography. By H. B. MILNER, M.A., D.I.C., F.G.S., Lecturer in Oil Technology, Royal School of Mines. 8*s*. 6*d*. net. Postage 5*d*.

"As a text-book for the more experienced student, no less than for the beginner, it is admirable."—*Mining Magazine.*

Thos. MURBY & Co., 1 Fleet Lane, Ludgate Circus, E.C.4.

BOOKS PUBLISHED AND SOLD

BY

DULAU & CO., LTD., 34-36 MARGARET STREET,
CAVENDISH SQUARE, LONDON, W.1.

NOW READY.

RAY SOCIETY Volume for 1923.

The British Charophyta.

By JAMES GROVES, F.L.S., and GEORGE RUSSELL BULLOCK WEBSTER, M.A., F.L.S. Volume II *Chareæ* with plates, concluding articles, Geological Sketch, Bibliography and Index. pp. i-xi + 1-129 8vo. with 25 plates (XXI-XLV). 8vo. Cloth, 1924, £1 5*s*. net.

(Vol. I *Nitellæ*, 1920, £1 5*s*. net).

Palæontographical Society. Vol. LXXV.

(Containing (1) Monograph of the Ammonoidea of the Gault. By L. F. SPATH, D.Sc., F.G.S. Part I, pp. 1-72; plates i-iv. (2) The Pliocene Mollusca of Great Britain. By F. W. HARMER, Hon. M.A. Cantab, F.G.S., F.R.Met.S. Vol. II, Part III, pages 705-856; plates lvii-lxiv. 4to. £1 5*s*. net.

A Geological Map of the Caucasus.

With explanatory text. By FELIX OSWALD, D.Sc., F.G.S. Compiled from the latest sources. Scale 1: 1,000,000 (15·78 miles = 1 inch). The geological formations and the igneous rocks are clearly displayed in twenty different colours. The glaciers are also indicated. All heights are given in English feet, and the latest railways have been inserted. The pamphlet of explanatory text gives a brief account of the main physical divisions of the Caucasus, followed by a detailed description of the successive geological horizons with their characteristic fossils. Special care has been taken to indicate the exact position in the geological series at which petroleum occurs in the Caucasian oil-fields. 15*s*. net. Postage 1*s*.

Table of British Strata.

Compiled by HENRY WOODWARD, LL.D., F.R.S., F.G.S., HORACE B. WOODWARD, F.R.S., F.G.S. 5*s*. net. Folded in book form 7*s*. 6*d*. net. Postage 1*s*.

IN PREPARATION.

CATALOGUE OF GEOLOGICAL WORKS,

including the Library of the late Sir JETHRO J. H. TEALL, F.R.S.

London: DULAU & CO., Ltd.
34-36 Margaret Street, Cavendish Square, W. 1.

Messrs. DULAU & CO., Ltd.

(for over a century at 37 Soho Square)

34-36 Margaret Street, Cavendish Square,
LONDON, W.1
(*close to Oxford Circus*).

A large and constantly changing Stock of

NATURAL HISTORY BOOKS

both New and Second-hand of Works on

ORNITHOLOGY, GENERAL ZOOLOGY, BOTANY, GEOLOGY, PHYSICS, and MEDICINE.

Catalogues issued at frequent intervals on the above subjects. No. 119 : Astronomy and Physics. Gratis on application.

LIBRARIES PURCHASED.

Telephone—MAYFAIR 3809. Cables—CHAUSCRIPT, LONDON.
Telegrams—CHAUSCRIPT, WESDO, LONDON.

NATURAL HISTORY BOOKS

AND PERIODICALS
Including the Publications of the Learned Societies
AND
A LARGE COLLECTION ON GEOLOGY
ON SALE BY

WHELDON & WESLEY LTD.

2, 3, & 4 Arthur St., New Oxford St., London, W.C.2.
CLASSIFIED CATALOGUES SENT POST FREE. BOOKS PURCHASED.
Agents for the sale of the Publications of the British Museum and the Government of India. Agency of the Smithsonian Institution of the United States, Washington, D.C.

All Communications for the EDITOR should be addressed to

Dr. R. H. RASTALL, Christ's College, Cambridge.

Books and Specimens to be addressed to the Editor as usual, care of

MESSRS. DULAU & CO., LTD., 34-36 MARGARET STREET, CAVENDISH SQUARE, W. 1.

STEPHEN AUSTIN AND SONS, LTD., PRINTERS, HERTFORD.